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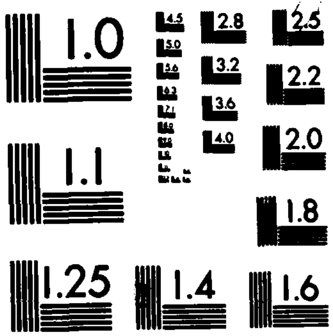


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REPORT BR 900192

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# COMPARISON OF FOUR CAMOUFLAGE NET STAKES IN SANDY SOILS


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JULY 1983

TEST REPORT

Prepared For:

Camouflage Application Branch

Counter Surveillance and Deception Division

Combined Arms Support Laboratory

U.S. ARMY MERADCOM

Fort Belvoir, Virginia 22060



BRUNSWICK DEFENSE

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| Stake | Camouflage | Sandy Soils |
| Ground Anchor | Camouflage Support System | Sand Soils |
| Camouflage Stake | Camouflage Screen | Test |
| Tent Pin | Sand | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains an evaluation of the performance of four camouflage net stakes in three types of sandy soils. The force which caused stake creep and the maximum holding force were determined for two stake inclinations and two pull angles. The results of the tests on the anchoring capability of the stakes show that the type 7 developmental stake is superior to the standard stake (type 1), the modified Artic stake (type 3), and the second developmental stake (type 6) in all soils and in all stake/force geometries. Deformation of both developmental stakes was observed and recommendation was made to overcome this shortcoming by heat treatment or by increasing the thickness of the metal.

## PREFACE

This stake comparison was performed in accordance with Contract No. DAAK70-80-C-0189 by the Brunswick Corporation, Defense Division, DeLand, Florida.

The intent of the test was to determine if three developmental stakes could provide a greater holding force in sandy soils than current standard stakes.

Recognition is gratefully made of Mr. Dave Griffis, of the Volusia County Soil Conservation Office, who was of great assistance selecting and locating the types of soils used to test the stakes and in obtaining permission from landowners.

This work was performed under the capable supervision of Robert G. Pearce, Development Engineering Manager and Charles E. Green, R&D Department Manager. The technical advice and suggestions as well as the providing of the developmental stakes by Mr. George Anitole of MERADCOM was certainly indispensable. Mr. Thomas T. Steck of MERADCOM, Contracting Officer's Representative, also was a key individual in this effort.

The cheerful and willing attitude of David E. Berger made short work of what could have been a tedious task. Becky Bristol and Nona Pflug swiftly and skillfully dealt with any and all of the many changes to the test plan and this report. Their contributions are happily acknowledged.

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## Section 1

## INTRODUCTION

### 1.1 SUBJECT

This Test Report contains information pertinent to testing which was conducted to determine performance of four types of stakes driven into three types of sandy soil. These stakes are being considered as ground anchors for camouflage screens.

### 1.2 PURPOSE

The purposes of this evaluation were to determine, for three types of sandy soil and for four types of stakes:

- The force at which the stake begins to move or creep and the maximum holding force of each stake for two stake inclinations and for two inclinations of the pulling force;

- The behavior of the stake during the test.

### 1.3 SCOPE

This comparison was concerned only with the relative performance of the four stakes tested as ground anchors in sandy type soils. Neither the optimum design nor the producibility of these stakes were of concern.

### 1.4 BACKGROUND

Two stakes are currently supplied for use with the U.S. Army standard Lightweight Camouflage Screening System. The Stake, Anchor, Snow, NSN 1080-01-075-4017, is supplied as part of the Camouflage Screen Support System, Snow, NSN 1080-00-556-4954, MIL-C-52765, Class 2[1] and is intended for use with Camouflage Screening System, Modular, Lightweight, Synthetic-Snow, MIL-C-52933[2]. The Stake, Aluminum, NSN 1080-00-108-1654, is supplied as part of the Camouflage Screen Support System, Woodland, NSN 1080-00-108-1173, MIL-C-52765, Class 1, and is intended for use with Camouflage Screening System, Modular, Lightweight,

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1 "Camouflage Screening Support Systems", MIL-C-52765B(ME), 27 September 1977, Amendment 1, 10 February 1981

2 "Camouflage Screening System, Modular, Lightweight, Synthetic-Snow", MIL-C-52933(ME), 21 September 1977

Synthetic, MIL-C-52771, Class 1 - Woodland - and Class 2 - Desert[3]. Both of these stakes are described in MIL-P-501[4].

Neither of these stakes perform satisfactorily when used in loose, dry sand. The sturdy design of the snow stake resists the large forces required to drive it into ice or frozen ground. The large bearing strength of ice or frozen ground enable this snow stake to develop adequate anchoring force in spite of its small bearing area. The bearing strength of sand, however, is so low that neither stake develops adequate anchoring force in this type soil.

This evaluation was part of an effort by MERADCOM to develop a stake for use in sand and sandy type soils.

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3 "Camouflage Screening Systems, Modular, Lightweight, Synthetic", MIL-C-52771A(ME), 23 February 1976, Amendment 1, 11 February 1981

4 "Pins, Tent, Metal", MIL-P-501, 4 December 1974

## Section 2

## INVESTIGATION

### 2.1 TECHNICAL APPROACH

The technical approach used in the current comparison was similar to those used in previous stake evaluations. In reference 5, stakes were driven vertically and inclined 30° from the vertical. The directions of pull were 30°, 45°, and 60°, from the vertical and also along the direction of the stake (pullout direction). The height above the soil for the point of application of the force was varied from 3 to 12 inches. The number of trials at each test situation was five or six. In reference 6, a single pull direction (30° - 40° from the horizontal) was used and three stake inclinations (perpendicular to the tension, vertical and parallel to the tension) were used.

The technical approach used in the current effort was to measure both the force at which stakes begin to move (or creep) and the maximum force developed by candidate stakes driven in selected sand type soils. The stakes were driven in the sandy type soil either vertically or inclined 30° from the vertical and away from the direction of pull. The point of application of the force on the stake was at ground level. The directions of pull tested were either 30° or 60° from the horizontal (typical slopes of a camouflage screen at ground level).

In all, 480 data points were recorded (creep and maximum force for five trials each of four stakes at two stake inclinations and two pull directions in three types of sandy soil).

### 2.2 TEST STAKES

The test stakes are described in figures 1 through 7. Stakes 1 and 2 are the standard camouflage stakes described in section 1.4. Stake 3 is made by welding a "wing" to stake 2. The remaining stakes were those fabricated and supplied by MERADCOM. Stakes 4, 5, and 6 differ only in those features that extend above the soil. Of these three, only stake 6 was tested since it has a positive cable retention feature (pin welded to the back of the stake).

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[5] "Single Stake Holdfast Test, Soil - Virgina Loam, Mason's Farm - Fort Belvoir, Va", Drawing G-9-D-3409, U.S. Army Corps of Engineer, The Engineer Board, Fort Belvoir, Va., Drawn 5-1-43

[6] "Test of New QM Cast Aluminum Alloy Ground Anchor and Navy Aircraft Mooring Anchor", Project 8-31-03-107, 6 April 1956

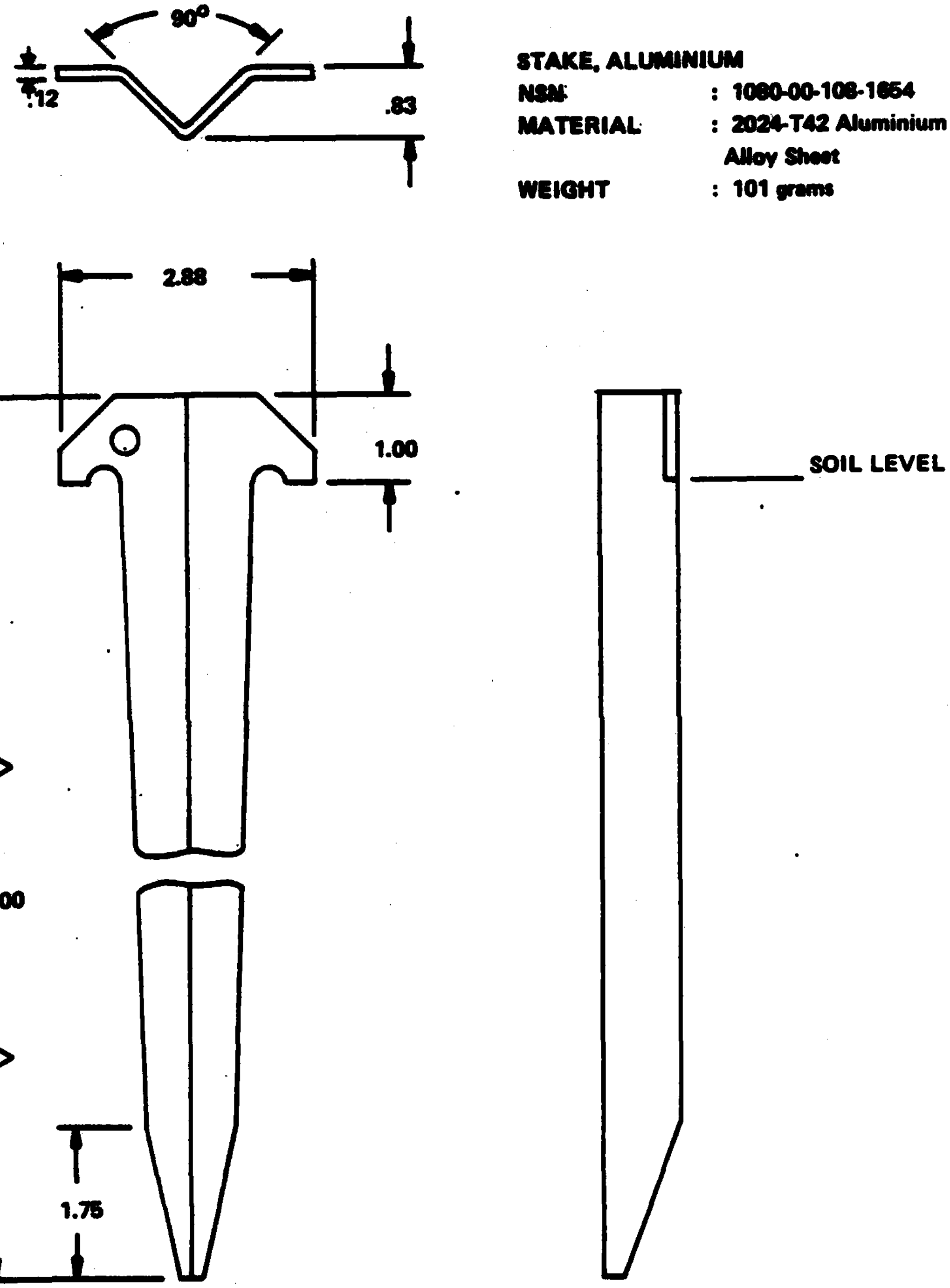


Figure Stake Type 1

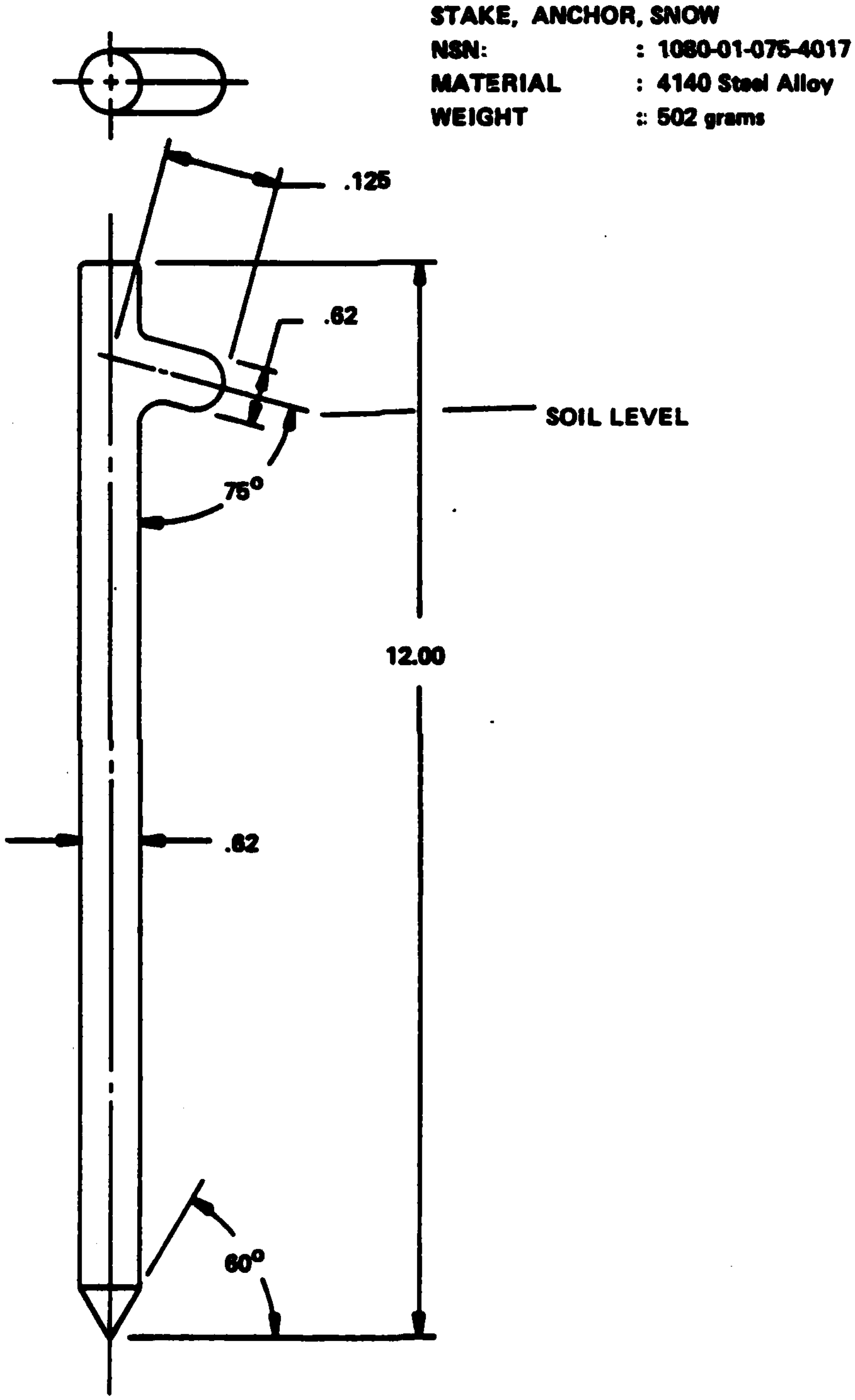


Figure 2 Stake Type 2

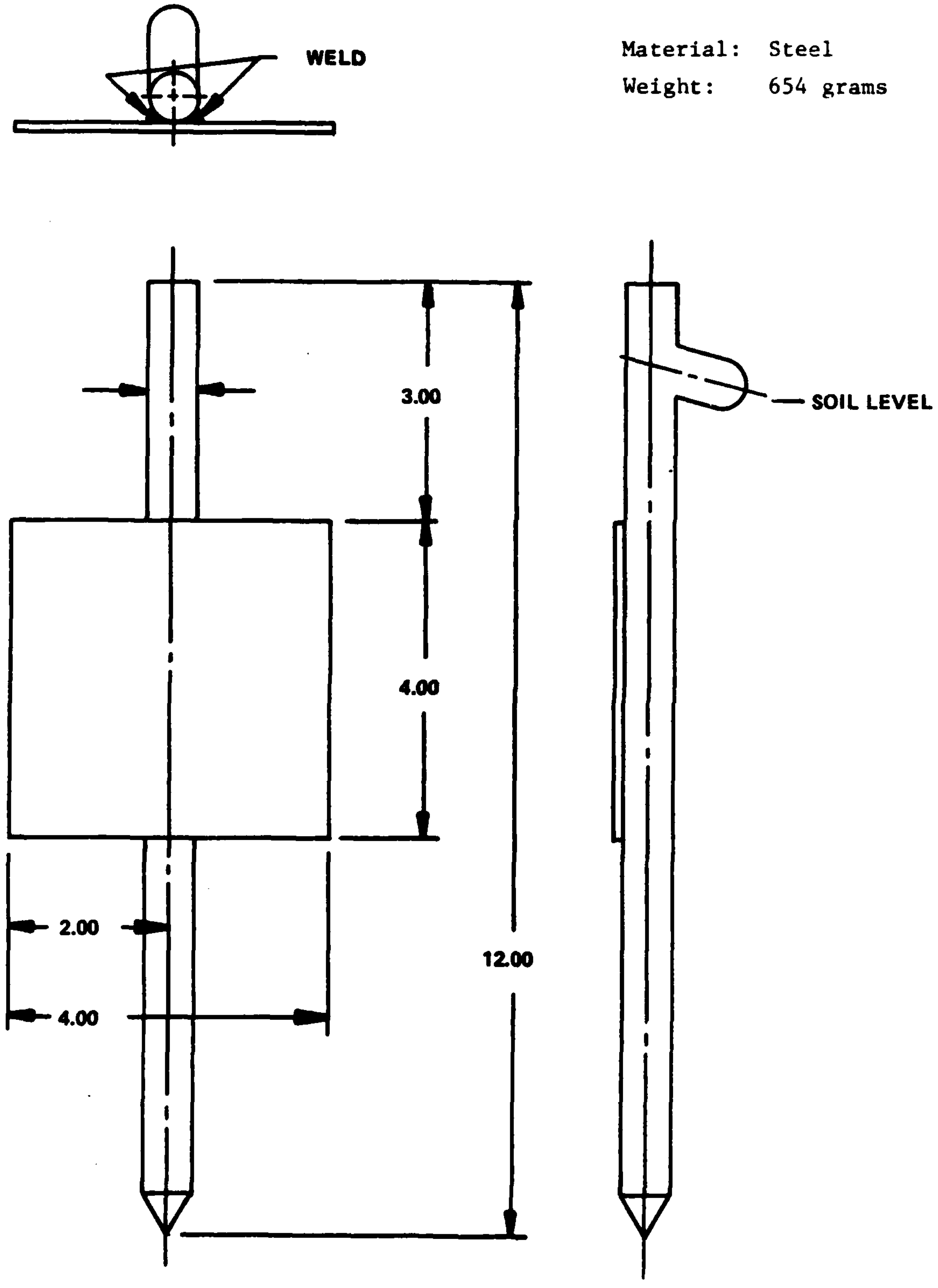


Figure 3 Stake Type 3

Material: Low Carbon Steel Sheet

Weight: 357 grams

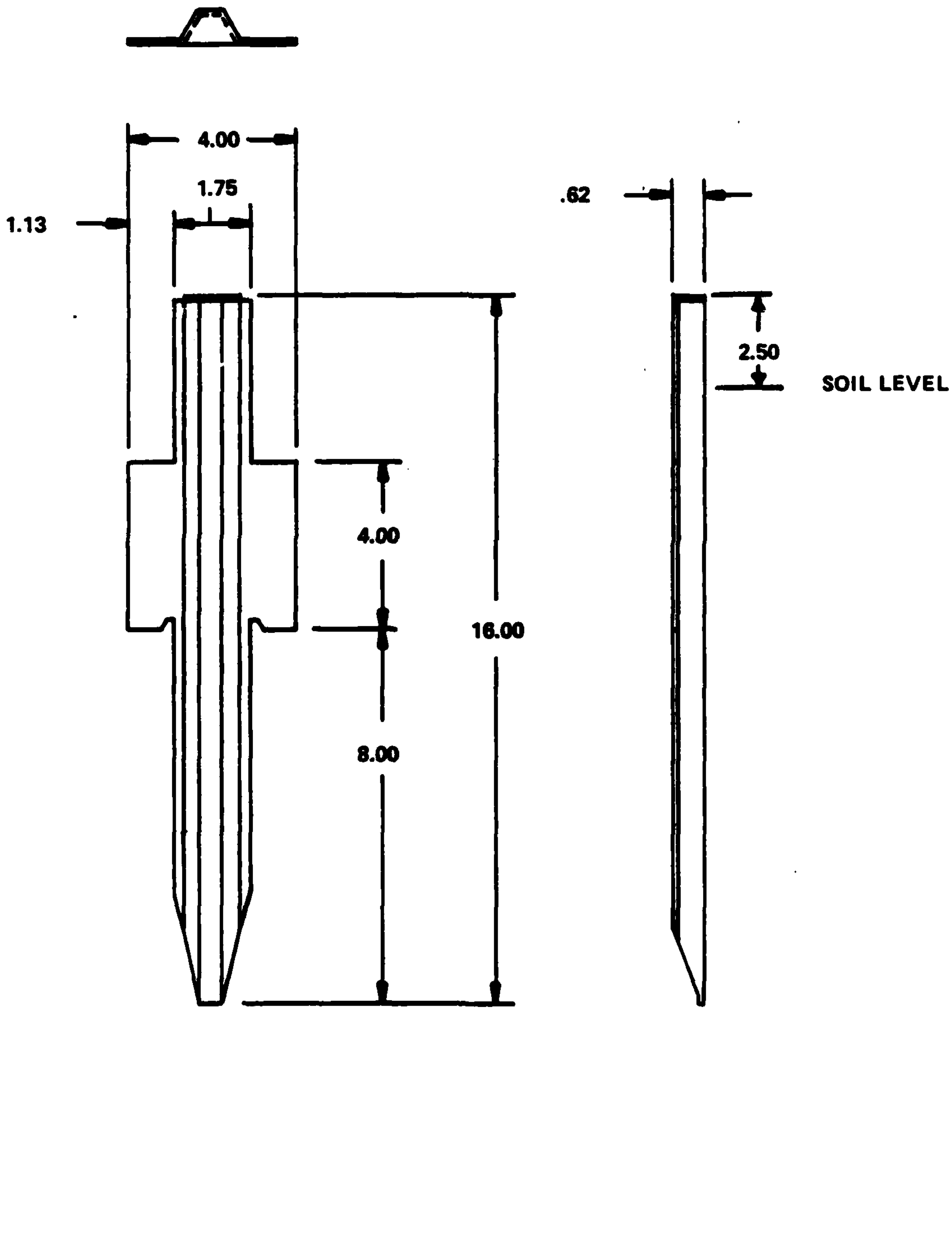


Figure 4 Stake Type 4

Material: Low Carbon Steel Sheet

Weight: 385 grams

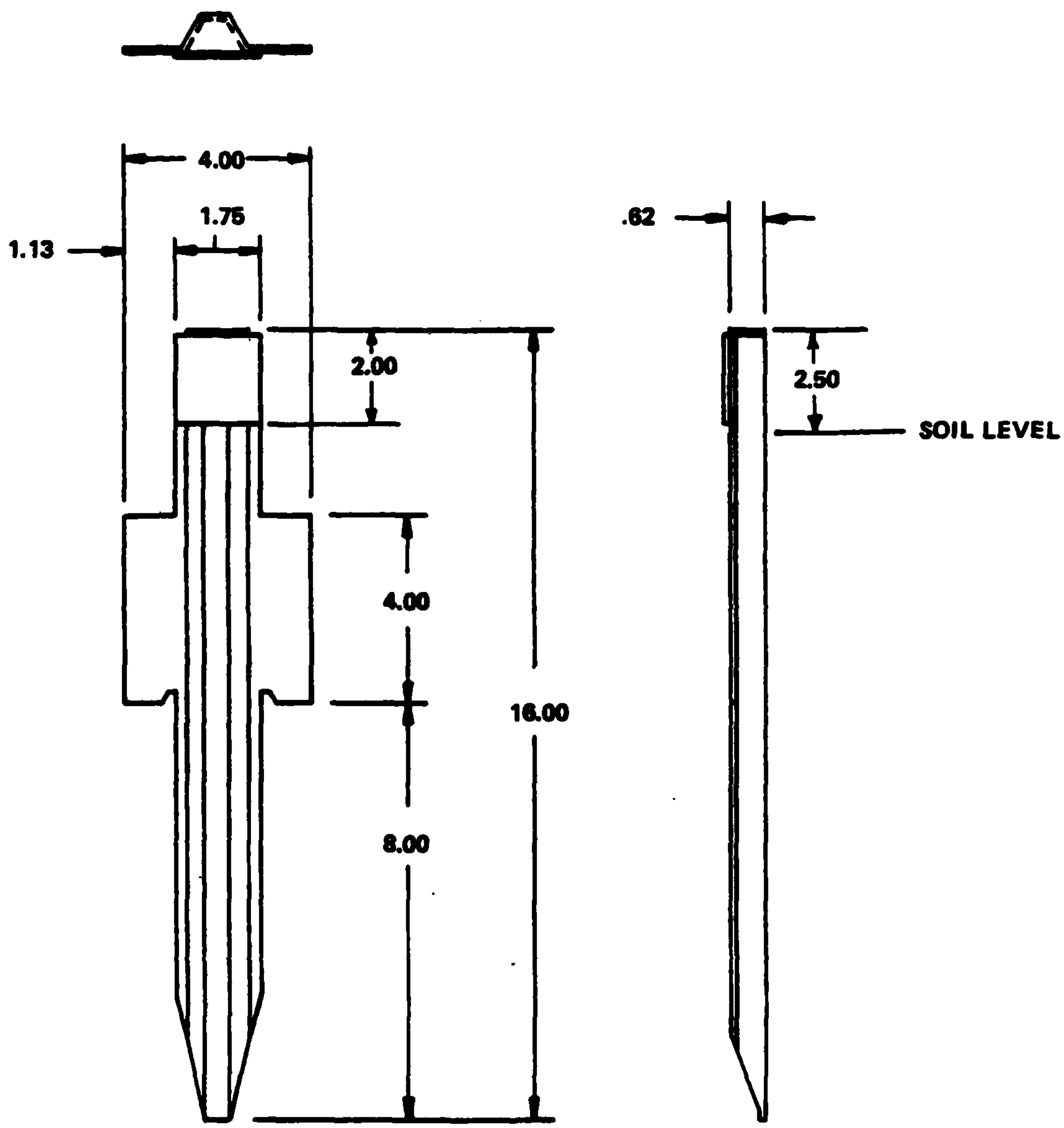


Figure 5 Stake Type 5

Material: Low Carbon Steel Sheet(1020)
Weight: 389 grams

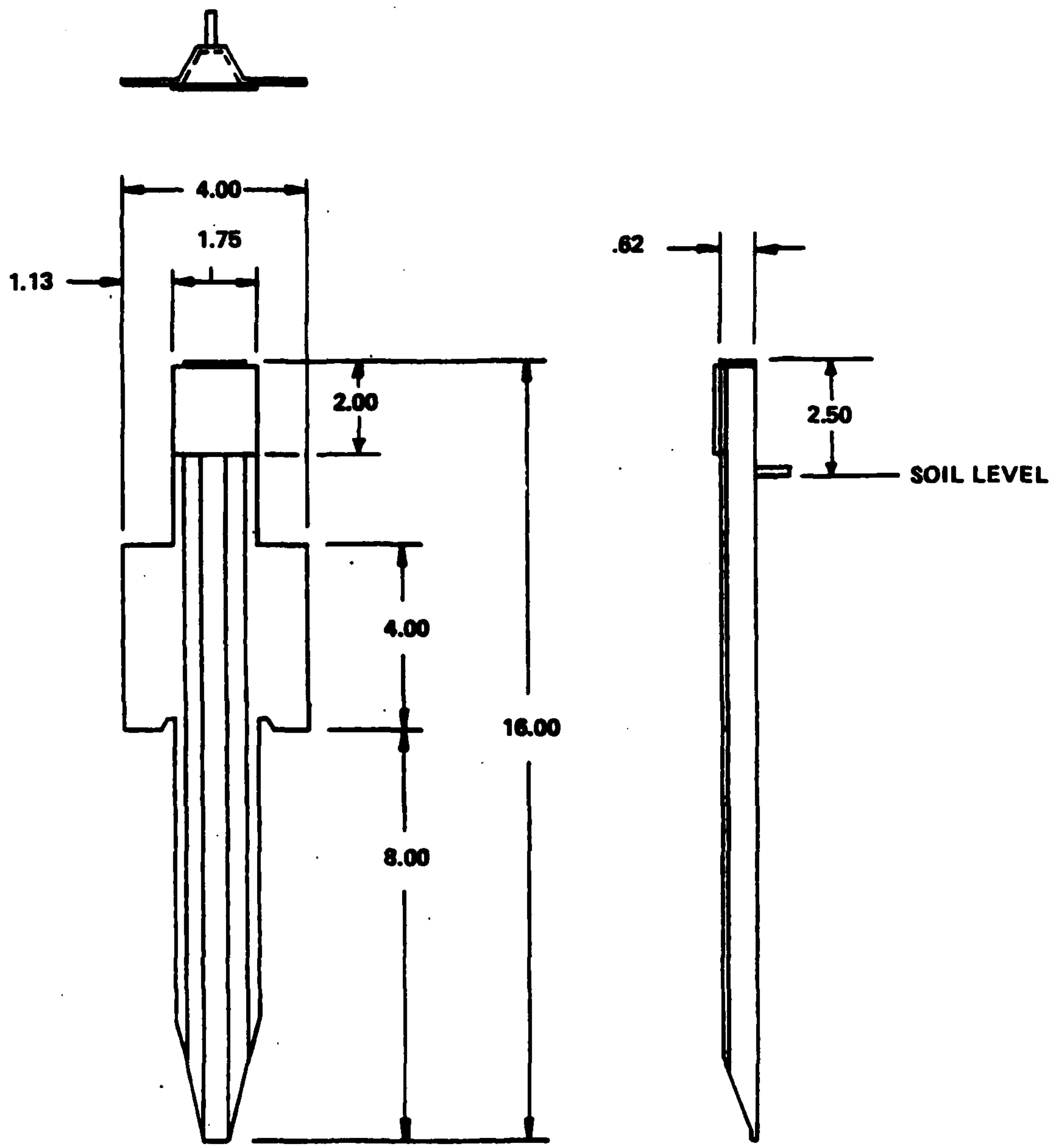


Figure 6 Stake Type 6

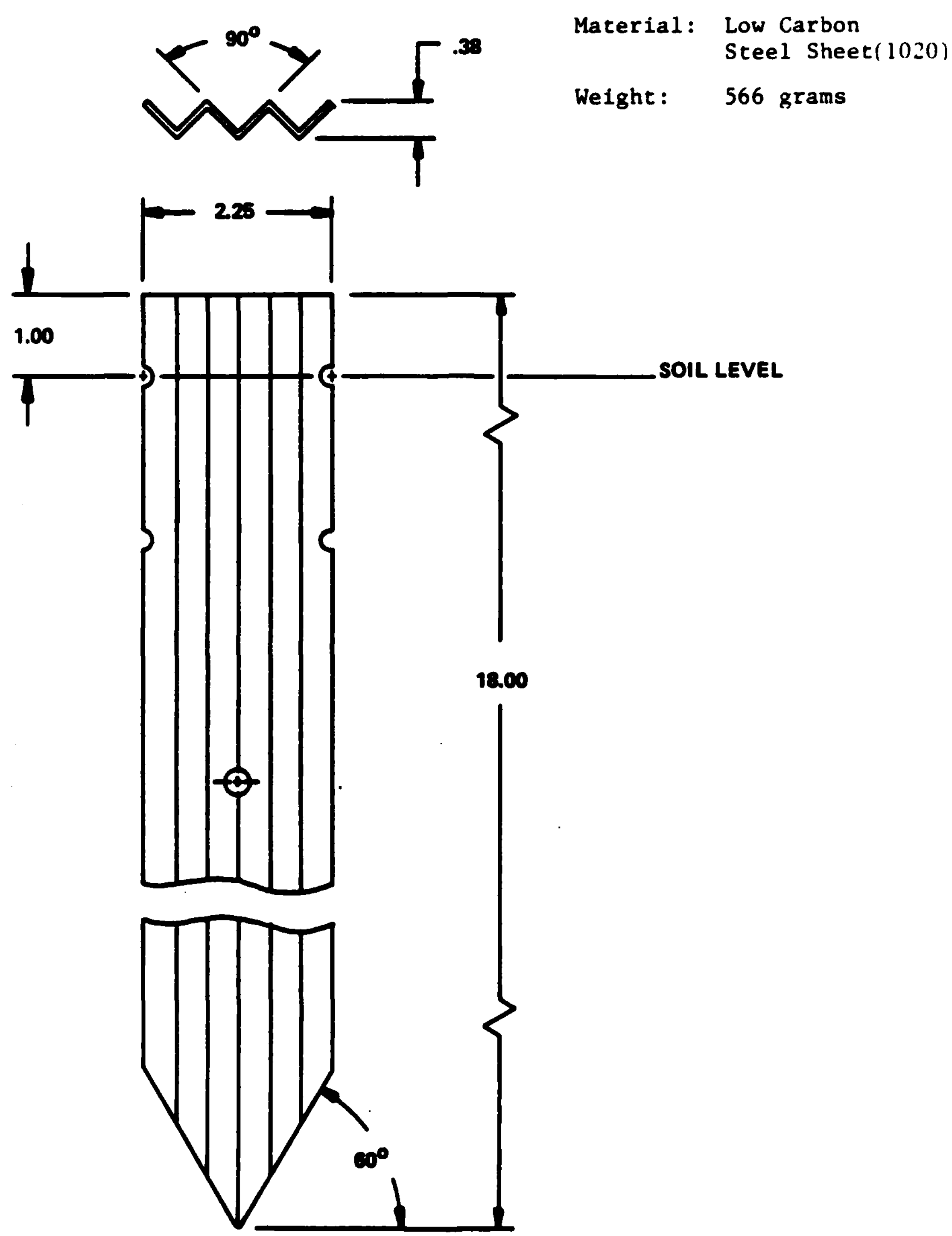


Figure 7 Stake Type 7

## 2.3 TEST SITES AND SOILS

The major intent of this test was to determine a stake suitable for use in sandy type soils. The soils of interest are briefly described as loose, coarse sand containing pebbles and other larger aggregate. No estimate of the percentage of aggregate or homogeneity of the soil, down to approximately 25 inches, was given.

The "Soil Survey for Volusia County, Florida"[7], by the U.S. Department of Agriculture Soil Conservation Service was examined to select local soils as similar as possible to the described sandy soil. Three of the 77 types of sandy soils found in Volusia County were selected for the stake tests. These soils are described in table 1. A detailed physical description of each site is given.

### 2.3.1 Palm Beach Soil Location

Palm Beach Soil is found at Test Site 1 in figure 8. The site was approximately 2,000 feet north, north-west of the light house on the north side of Ponce Inlet on the Atlantic coast in Volusia County. The site was near the top of sand dunes about 1,500 feet inland from the beach. It has been, as far as could be ascertained, undisturbed for several years. The site contained clumps of palmetto, trees up to 8 inches in diameter and other clumps of brush all scattered at intervals of 10 to 20 feet. The soil surface was mostly covered with leaves and some grass. Shells and shell fragments were plentiful in the soil. The soil which is normally dry contained little organic material.

### 2.3.2 Bulow Soil Location

The Bulow soil tested is found at Test Site 2 in figure 8. The site was in Ormond Beach, Florida, approximately 2,000 feet north of the intersection of State Route 40 and State Route 5A and located between the Trails Shopping Center and the entrance to the Trails Subdivision. The site contained trees up to 12-15 inches in diameter, palmetto clumps and other brush. The site contained areas of thick brush and several open spaces of 20-30 feet across. The open spaces, used for the test, were covered with leaves and contained a few small vines. The soil which is normally dry contained somewhat more organic material than the Palm Beach soil and an occasional small piece of coquina rock.

### 2.3.3 Smyrna Soil Location

The Smyrna soil test site is Test Site 3 in figure 8. The site was located on Brunswick property immediately west of the DeLand plant. The site contained no trees or brush but was covered with relatively thick grass. The soil contains significant organic material but few shells or pebbles. Smyrna soil is normally damp.

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7 "Soil Survey of Volusia County, Florida", United States Department of Agriculture, Soil Conservation Service, February 1980

Table 1

Soil Characteristics

| SOIL | MORPHOLOGY | pH RANGE | PERMEABILITY IN. $H_2O$/HR. | DEPTH OF WATER TABLE | PERCENT PASSING THROUGH SEIVE NO. 10 | 40 | 200 | REMARKS |
|---|---|---|---|---|---|---|---|---|
| Site 1 Palm Beach Sand, #39 in Soil Survey | Top 6 inches consist of sand containing very fine shell fragments. The sub-surface layer, 6 to 34 inches, is sand mixed with larger shell fragments. Shell content ranges from 15 to 30% | 7.4-8.4 | 20 | >6 ft | 75-90 | 15-90 | 1-4 | Medium & fine roots common. Normally found on old dunes near the Atlantic Ocean. |
| Site 2 Bulow Sand, #11 in Soil Survey | Top 5 inches are a loose single grained sand. The sub-surgace layer, 5 to 20 inches, is very similar with more and larger roots with organic matter. | 5.1-7.3 | 6-20 | >6 ft | 100 | 70-90 | 1-4 | Many fine rootlets in top 5 inches. Medium & fine roots in 5-20 inch layer. Normally found on low sand ridges which were, many years ago, on the coast line. |
| Site 3 Smyrna Sand, #60 in Soil Survey | Top 8 inches consist of fine sand of medium granular structure. The sub-surface layer, 8 to 19 inches, is fine sand, single grain structure. Essentially no pebbles or aggregate. | 3.6-7.3 | 6-20 | 0-1 | 100 | 80-100 | 2-10 | Many roots of all sizes in top 8 inches; medium roots in 8-17 inch layer. Of marine sediment origin. |

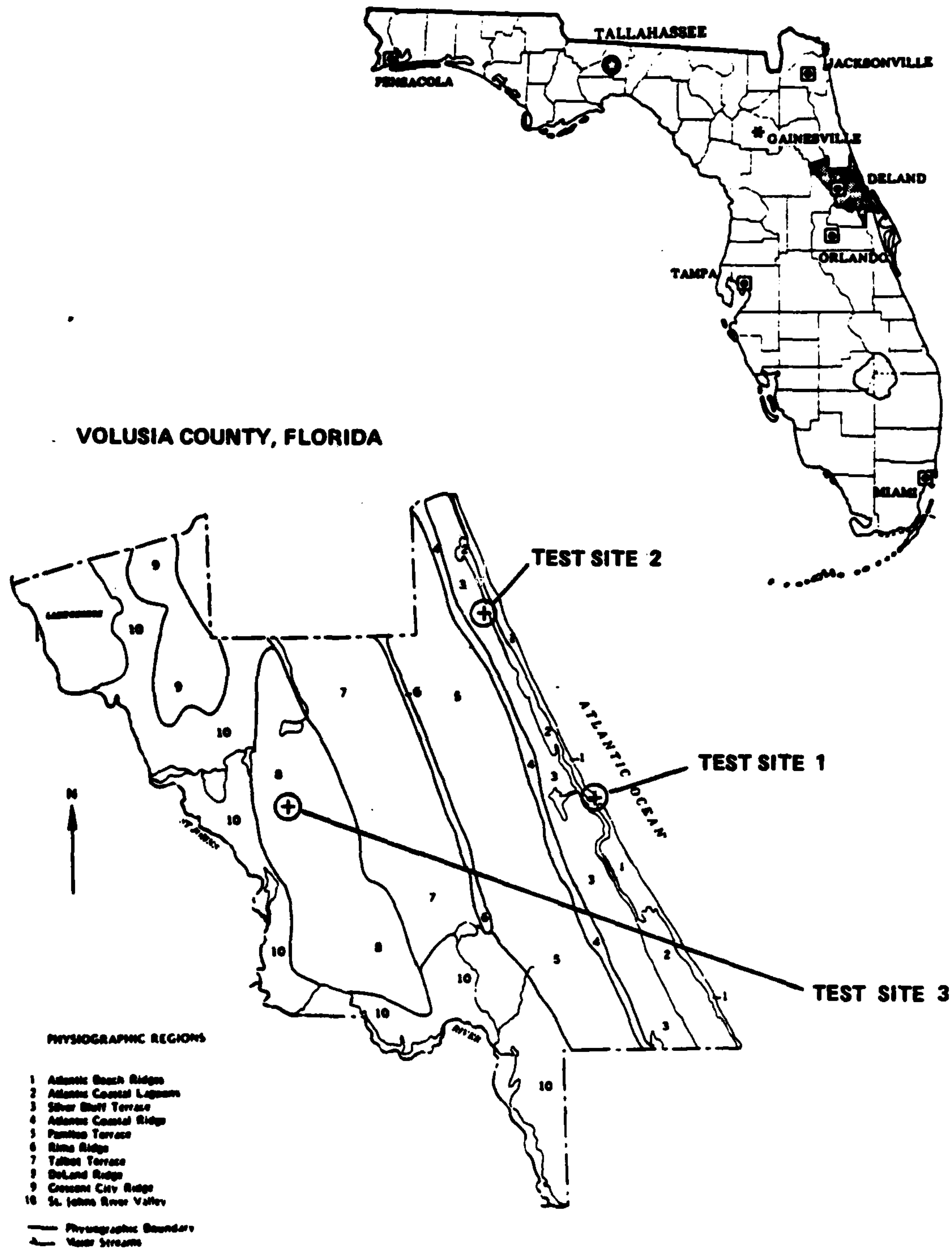



Figure 8 Test Site Locations

## 2.4 TEST APPARATUS

The test data were determined by means of the apparatus shown in figure 9. This apparatus, along with a maul for driving the stakes, was packed in a case for transport to field test sites.

The force against the stakes was generated by a cable winch puller of 1000 pounds capacity which pulled the test stake toward a ground anchor of greater holding force than the test stakes. The frame was used to control the inclination of the force on the stake.

The magnitude of the force was measured by a Chatillon Type 160 500-pound spring scale graduated in 5-pound increments.

The inclination of the cable attached to the test stake was measured by a Pro Angle and Level Finder protractor with a dial indicator specified accurate to one half of 1°.

Both of these instruments were calibrated before and after the series of tests described in this Test Report. The spring scale was calibrated on an Instron testing machine. On both tests, the spring scale was accurate throughout its entire range to within one scale division (5 pounds). The protractor was tested and found to be within the advertized accuracy.

## 2.5 TEST PROCEDURE

The following procedural steps were performed at each test site:

- Select a clear test area.
- Set the ground anchor.
- Drive the test stake ± 5° of the desired inclination.
- Measure stake inclination.
- Adjust the frame such that the cable inclination, under moderate tension, is the desired value ± 5°.
- Increase cable tension until the stake is pulled out of the ground.
- Record both the scale reading at which the stake begins to move (creep) and the maximum scale indication reached prior to pulling the stake out of the ground.
- Repeat the above process for a total of five trials at different stake locations at each of four stake-force inclination geometries.

The direction of pull for each type stake tested is shown in figure 10.

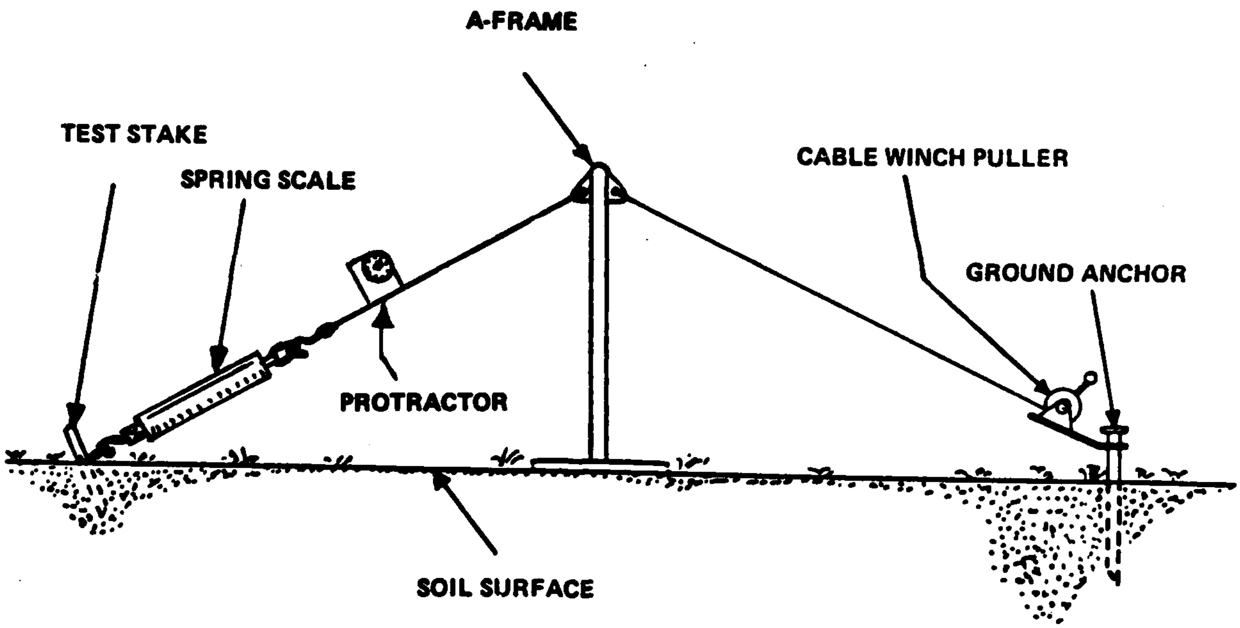



Figure 9 Stake Test Apparatus

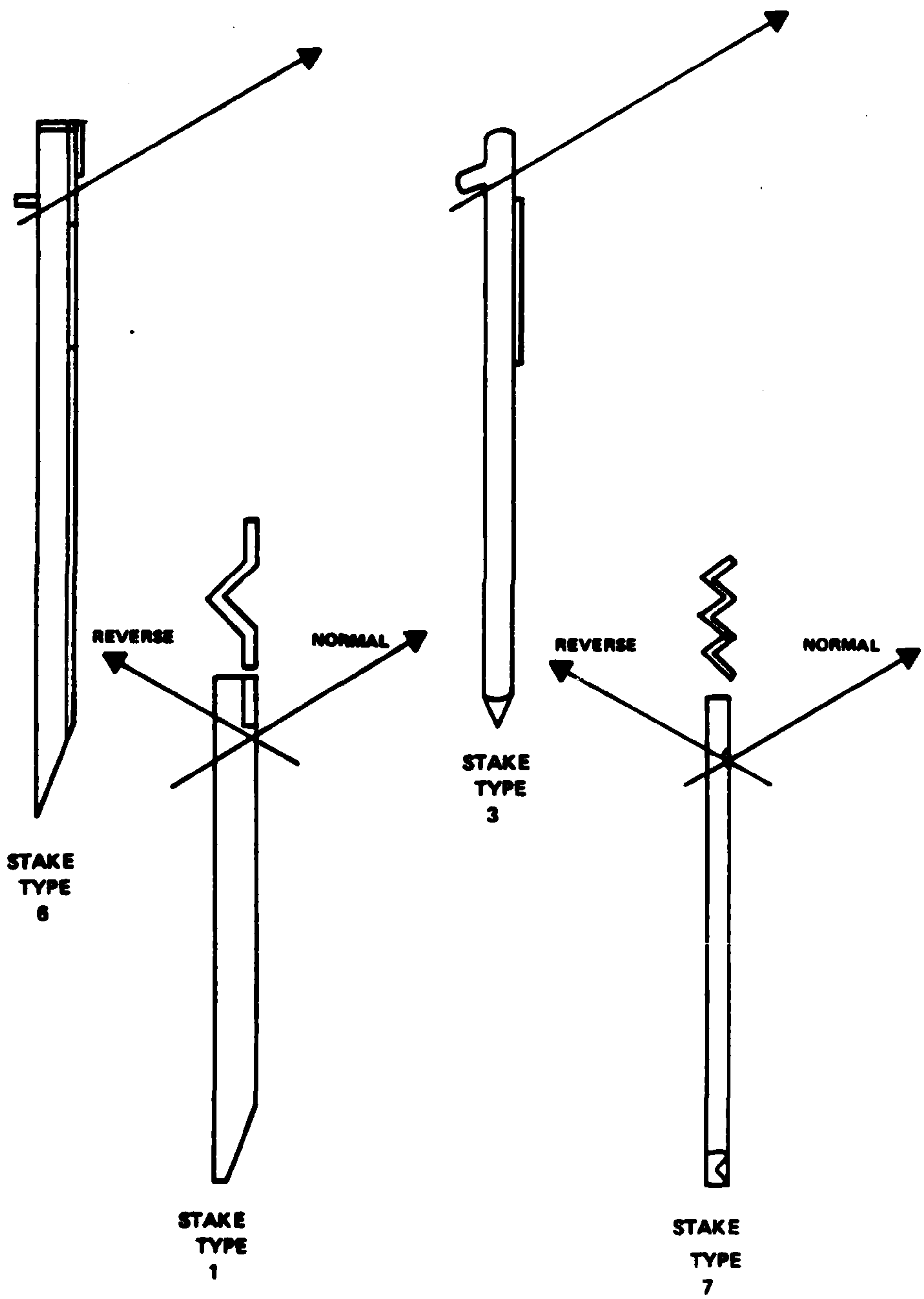



Figure 10 Pull Force Directions

# Section 3

# RESULTS

## 3.1 TEST DATA SHEETS

The results of the field tests were recorded on the test data sheets contained in the appendix. Each data sheet contains the results of one stake design tested in one soil type.

## 3.2 TEST DATA SUMMARY

The average forces shown on the Test Data Sheets are summarized in table 2.

## 3.3 OBSERVATIONS ON STAKE PERFORMANCE

In most of the trials the stakes could be easily driven into the sandy soils tested. Frequently Type 1 and Type 3 stakes could be driven into the soil by applying pressure with the foot. Driving the stakes into sandy soil caused no major deformation of the stakes unless a hard object, such as a root, below the surface was struck. The one instance noted was deformation of one wing of a Type 6 stake.

The Type 7 stakes became battered at the top driving surface toward the end of the test. This could be expected since there were only two stakes available for use and a total of approximately 90 trials (Smyrna Soil tests were conducted twice) were conducted using the two stakes. Battering deformation was not noted on the Type 1 and Type 3 stakes. Some battering was noted on the Type 6 stake (but not nearly so much as on Type 7). The limited or no battering occuring on the Types 1 and 6 stakes may be attributable to the fact that the usage was spread among five or more stakes of each type. The Type 3 stake (modified arctic stake) showed no ill effects even though only one stake was used throughout the trials. The arctic stake is very sturdy, indeed.

Driving force of the different stakes was roughly proportional to their lengths and cross-sections. The Type 1 and 3 stakes being shorter could be pushed into the ground with one's foot. The Type 3 stake did exhibit resistance when the welded-on wing encountered grass or roots.

During pull-out the Type 1 and 3 stakes suffered no deformation. The Type 6 and 7 stakes, being longer and offering greater resistance to pull than the Type 1 and 3 stakes, bent under higher loads. The Type 6 stake always bent at the lower edge of the "wing". The Type 7 stake bent in the vicinity of the center hole. Because of the necessity to reuse these stakes, they were straightened after each trial.

## Table 2

### Average Resistance Force of Camouflage Net Stakes in Sandy Soils

| Stake Type | Stake Inclination | Force Inclination | Average Force, Pounds (Rounded to nearest interger) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Soil 1 | | Soil 2 | | Soil 3 | | All Soil Average | |
| | | | Creep | Max. | Creep | Max. | Creep | Max. | Creep | Max. |
| 1 | 60° | 60° | 28 | 35 | 38 | 55 | 107 | 183 | 58 | 91 |
| | 60° | 30° | 31 | 62 | 40 | 87 | 152 | 291 | 74 | 147 |
| | Vertical | 60° | 43 | 65 | 37 | 44 | 102 | 173 | 61 | 94 |
| | Vertical | 30° | 54 | 74 | 48 | 82 | 134 | 296 | 79 | 151 |
| | | Average | 39 | 59 | 41 | 67 | 124 | 236 | | |
| 3 | 60° | 60° | 28 | 34 | 29 | 39 | 95 | 197 | 51 | 90 |
| | 60° | 30° | 30 | 40 | 31 | 56 | 106 | 216 | 56 | 104 |
| | Vertical | 60° | 56 | 62 | 41 | 50 | 153 | 208 | 83 | 107 |
| | Vertical | 30° | 64 | 84 | 39 | 70 | 226 | 402 | 110 | 185 |
| | | Average | 45 | 55 | 35 | 54 | 145 | 256 | | |
| 6 | 60° | 60° | 75 | 97 | 64 | 108 | 160 | 269 | 100 | 158 |
| | 60° | 30° | 54 | 78 | 44 | 96 | 219 | 335 | 106 | 110 |
| | Vertical | 60° | 68 | 85 | 70 | 96 | 157 | 210 | 98 | 130 |
| | Vertical | 30° | 108 | 147 | 85 | 150 | 249 | 343 | 146 | 213 |
| | | Average | 76 | 102 | 66 | 113 | 196 | 289 | | |
| 7 | 60° | 60° | 81 | 121 | 52 | 104 | 119 | 293 | 84 | 173 |
| | 60° | 30° | 77 | 142 | 96 | 186 | 165 | 350 | 113 | 226 |
| | Vertical | 60° | 131 | 166 | 75 | 112 | 149 | 321 | 118 | 200 |
| | Vertical | 30° | 110 | 193 | 90 | 201 | 187 | 453 | 129 | 282 |
| | | Average | 100 | 156 | 61 | 151 | 155 | 354 | | |

From the testers' observations, it is estimated that both Type 6 and Type 7 stakes started to bend in the ground when the loads reached the 200-250 pound range. No attempt, under test conditions, was made to determine accurately the load at which bending began.

During testing the stake/force geometry of vertical stake and 60° (from horizontal) force produced a reaction not observed in the other geometries. As the load was applied to the stake, the stake would resist and then relieve the force by sliding upward vertically about one half to one inch and then hold again as the load increased. This slip and hold, slip and hold process might occur three times before a maximum force was reached and recorded.

As mentioned above, the type 6 and 7 stakes became battered from driving and bent by the pulling force. One stake of each type (6 and 7) was heat treated. The heat treating essentially corrected the deformation problems in both stakes (a small amount of battering after approximately 18 trials was noted). Under the test loads, it was noted that the two heat treated stakes would bend to some extent, but returned to their original configuration when the load was removed.

## Section 4

## DISCUSSION

### 4.1 PROCEDURE

The procedure followed in this testing was that previously described in paragraph 2.5. The apparatus was set up as shown in figure 9. Stakes were driven in an area centering on the anchor stake. The radius of the area used was approximately 15 feet or less. This ensured that the soil in any of the test sites was essentially homogenous. The stakes were driven into the ground approximately 15 to 20 inches from each preceding trial location. When driven into the ground, the stakes were held against a wood template cut at 90° and 60° (from the horizontal) angles. A pull loop of 3/16 steel cable was placed around the stake and then the stake was further driven until the loop retaining pin or notch touched the ground. This ensured that the pull always began at ground level. The pull loop was connected to the 500 pound capacity spring scale which was in turn attached to the A-frame by either a long or short cable. The short cable gave a pull force inclination of 60° ± 5°. The long cable gave a pull force inclination of 30° ± 5°. The A-frame was connected to the winch cable. The winch exerted a steady, slow, controllable pull on the stake via the A-frame. The creep point was determined as that force at which an actual displacement of the stake was felt by a finger placed lightly on top of the stake. The pull was continued until a maximum force was reached and passed. The readings, plus any pertinent comments, were recorded on the data sheets and the trial was repeated.

### 4.2 ANALYSIS OF DATA

For each stake type, soil type and combination of stake inclination and force inclination, a mean and standard deviation for both the creep force and the maximum force were calculated on the data sheets. Table 2 consolidates the creep and maximum forces for all tests.

#### 4.2.1 Anchoring Capability as a Function of Soils

In figure 11, the average anchoring capability of each stake in each of the soils tested is compared. The data are an average of all stake/force combinations and gives an estimate of the relative anchoring capability of each type stake. In Palm Beach and Bulow soils, there is essentially no difference between stake types 1 and 3. Stake type 6 exhibits twice the anchoring capability of stake types 1 and 3 while stake type 7 has three times the anchoring capability of types 1 and 3. In Smyrna soil the difference is not as pronounced, but type 6 and type 7 stakes are clearly superior to types 1 and 3.

Examination of the creep force for each type stake produces further information about the stakes. Data comparing the creep force as a percent of maximum force for each stake in each type of soil are presented in figure 12. Stake type 7 consistently creeps at a lower percentage of total anchoring capability

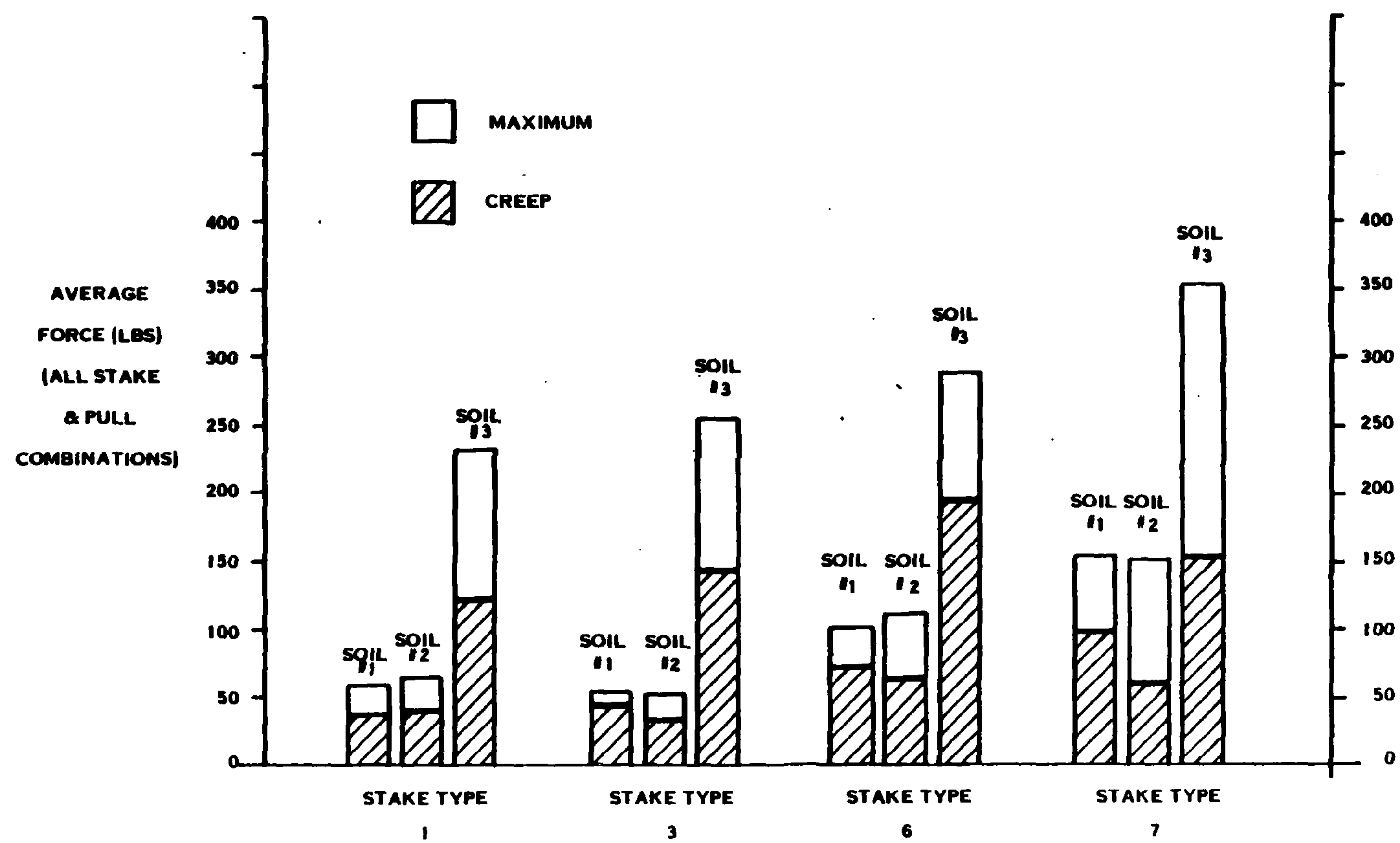



Figure 11 Anchoring Capability in Three Sandy Soils

| STAKE TYPE | SOIL TYPE 1 | 2 | 3 | AVERAGE |
|---|---|---|---|---|
| 1 | 66% | 61% | 53% | 60% |
| 3 | 82% | 65% | 57% | 68% |
| 6 | 75% | 58% | 69% | 67% |
| 7 | 64% | 40% | 44% | 49% |
| AVERAGE | 72% | 56% | 56% | 61% |

Figure 12 Creep as a Percent of Maximum Force (For All Geometries)

than types 1, 3, and 6. The explanation for the higher creep force as a percent of maximum load for stake type 1 has not been determined. For stake types 3 and 6, the greater bearing area of the "wings" or "paddles" on the stakes offer greater resistance to movement than the bearing area of type 7 stake.

Palm Beach soil shows the greatest average creep force percentage of the three soils tested. This is most likely due to the fact that Palm Beach soil is a dune type soil and is looser than Bulow or Smyrna. Therefore, once movement of the stake occurs in Palm Beach soil, the maximum force (or failure point) of the stake occurs quickly as the load is increased.

### 4.2.2 Anchoring Capability as a Function of Stake/Force Geometry

From examination of four combinations of stake inclination and force inclination depicted in figure 13, an evaluation can be made to determine the best way to use stakes. Data found in figure 14 enables a comparison of the average (for all soils) resistance of each type stake in each of the stake/force geometries to be made. This figure confirms the superior anchoring capability of type 6 and 7 stakes. In addition to comparing the different stakes, one can readily differentiate the effect that stake and force geometry have on the anchoring capability of any given stake.

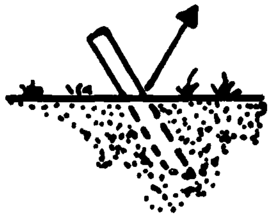
Geometries B and D for all stakes (except type 3, geometry B) exhibit better anchoring capability than geometries A and C. A major portion of this effect is attributable to the force inclination of 30° from horizontal in both configurations. The upward force component which produces stake pull-out is less for the 30° force than for the force inclination of 60° from horizontal.

The lesser factor in determining the holding power of the stake is the angle at which it is driven into the ground. For either force inclination, 30° or 60°, the stake driven into the ground vertically (with the exception of the type 6 stake at 60° force inclination) produces a greater anchoring capability than an inclined stake at the same force inclination. With all four types of stake, geometry D (vertical stake and 30° force inclination) gives the greatest holding power.

The creep force percentage of maximum force for each stake is affected by the stake angle and the force angle. Figure 15 presents data which allow the stakes in each of the four geometries identified in figure 14 to be compared. The creep force as a percentage of maximum force is lower for stake type 7 than all but one (it is equal) of the other stakes regardless of stake/force geometry. The same explanations for the differences in stakes given in paragraph 4.2.1 apply here.

The stake/force geometries B and D exhibit a consistent creep-to-maximum force relationship to geometries A and C respectively. The B and D geometries have the 30° force inclination in common while the A and C geometries have a 60° force inclination. Due to the greater upward component in the 60° force

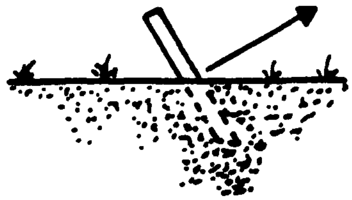
A.



STAKE INCLINATION - 60°

FORCE INCLINATION - 60°

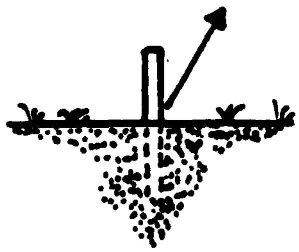
B.



STAKE INCLINATION - 60°

FORCE INCLINATION - 30°

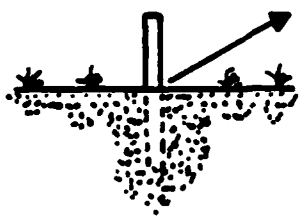
C.



STAKE INCLINATION - VERTICAL

FORCE INCLINATION - 60°

D.



STAKE INCLINATION - VERTICAL

FORCE INCLINATION - 30°

NOTE: ALL ANGLES MEASURED FROM HORIZONTAL.

Figure 13 Stake and Force Geometries

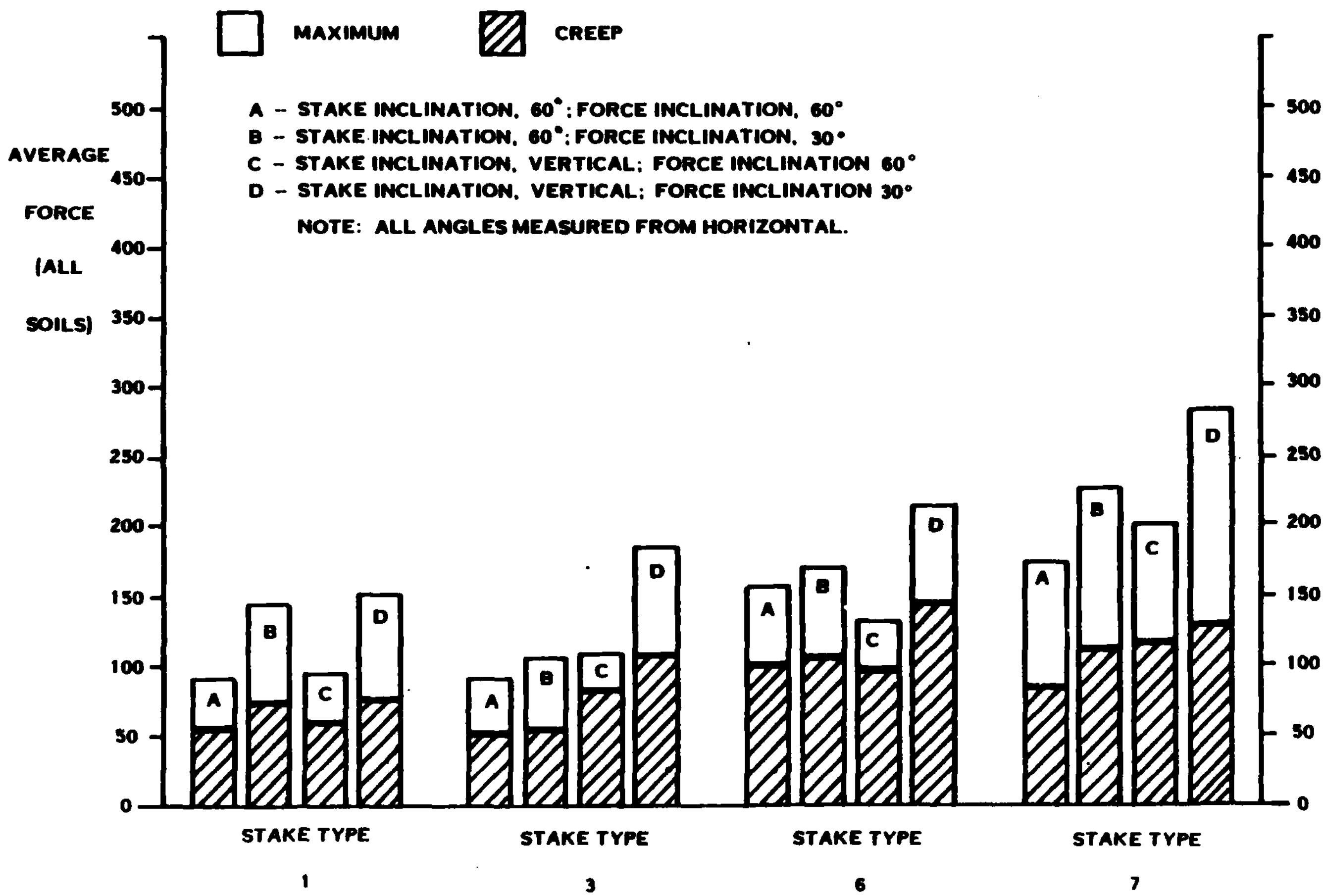



Figure 14 Comparison of Stake and Force Geometries

| STAKE TYPE | STAKE/FORCE GEOMETRY A | B | C | D | AVERAGE |
|---|---|---|---|---|---|
| 1 | 64% | 50% | 65% | 52% | 58% |
| 3 | 57% | 54% | 76% | 59% | 62% |
| 6 | 63% | 62% | 75% | 69% | 67% |
| 7 | 49% | 50% | 59% | 46% | 51% |
| AVERAGE | 58% | 54% | 69% | 57% | 60% |

Figure 15 Creep as a Percent of Maximum Force (For All Soils)

inclination, once movement or creep occurred in the stake, maximum force (or stake failure) occurred sooner after creep than in the 30° force inclination. Therefore the creep force constitutes a greater percentage of the maximum force for the A and C geometries than for the B and D geometries.

## 4.3 EFFECT OF REVERSING STAKES

During testing it was noted that stake types 1 and 7 could easily be reversed in driving them into the ground, i.e. front to back or back to front. Both the normal and the reverse directions of force for types 1 and 7 were indicated in figure 10. The front side of the stakes (the open sides of the 'Vee' or 'W' toward the direction of pull) was arbitrarily considered to be the normal direction. The pointed or closed sides of the 'Vee' or 'W' were considered to be the reverse direction. Stake types 3 and 6 were not considered likely to be reversed due to the rope retention lugs on the reverse sides.

The reversed configuration was partially tested in Smyrna soil only. The results of these tests are on data sheets 9A and 12A. Figure 16 depicts test data for the normal and reversed stakes in all stake and force combinations illustrated in figure 12 for type 1. For stake type 7 only geometries C and D were tested.

From figure 16, the 30° force inclinations, B and D, are again shown to be superior regardless of the facing of the stake. In the case of stake type 7, there is little effect in reversing the stake. In the case of type 1 stake, differences as much as 30 percent occur when the stake is reversed. The effect of reversing the stake changes whenever the stake angle changes. When the type 1 stake is driven into the ground at the 60° angle, the normal side towards the load exhibits the better holding power. When the type 1 stake is driven vertically, the reverse side of the stake towards the load holds a greater force.

Examination of figure 16 shows that in all but one comparison, reversing the stake increases the creep force as a percentage of maximum force. In four of six comparisons the actual creep force is increased by reversing the stakes.

Since the test trials in which the stakes were reversed were limited in number and to only Smyrna Soil, this report does not identify any significance with the differences in creep forces due to stake reversal.

## 4.4 EFFECT OF HARDENING STAKES

As mentioned in paragraph 3.3 above, a type 6 stake was heat treated ($R_c$ 49) as was a type 7 stake ($R_c$ 45). These stakes were tested on 14 July, 1983 in the Smyrna soil at the DeLand plant. Untreated type 6 and type 7 stakes were further tested at the same time in the same immediate vicinity to serve as controls. Data from these tests are given on data sheets 13 and 14. These data are compared in Table 3. Data from Table 2 are included in Table 3 for information. A statistical analysis of the difference in maximum forces

between the hardened and unhardened stake using the Student - T test shows that hardening the stakes has a significant effect on the maximum anchoring capability but not the creep points of the stakes. In most cases the hardening of the stake increased the maximum anchoring capability approximately 100 pounds. It is believed that the unhardened stake yields at a lower load because it bends and effectively changes the resistance angle of the soil.

The maximum force could not be determined in many trials because the forces exceeded the maximum capacity (500 pounds) of the spring scale.

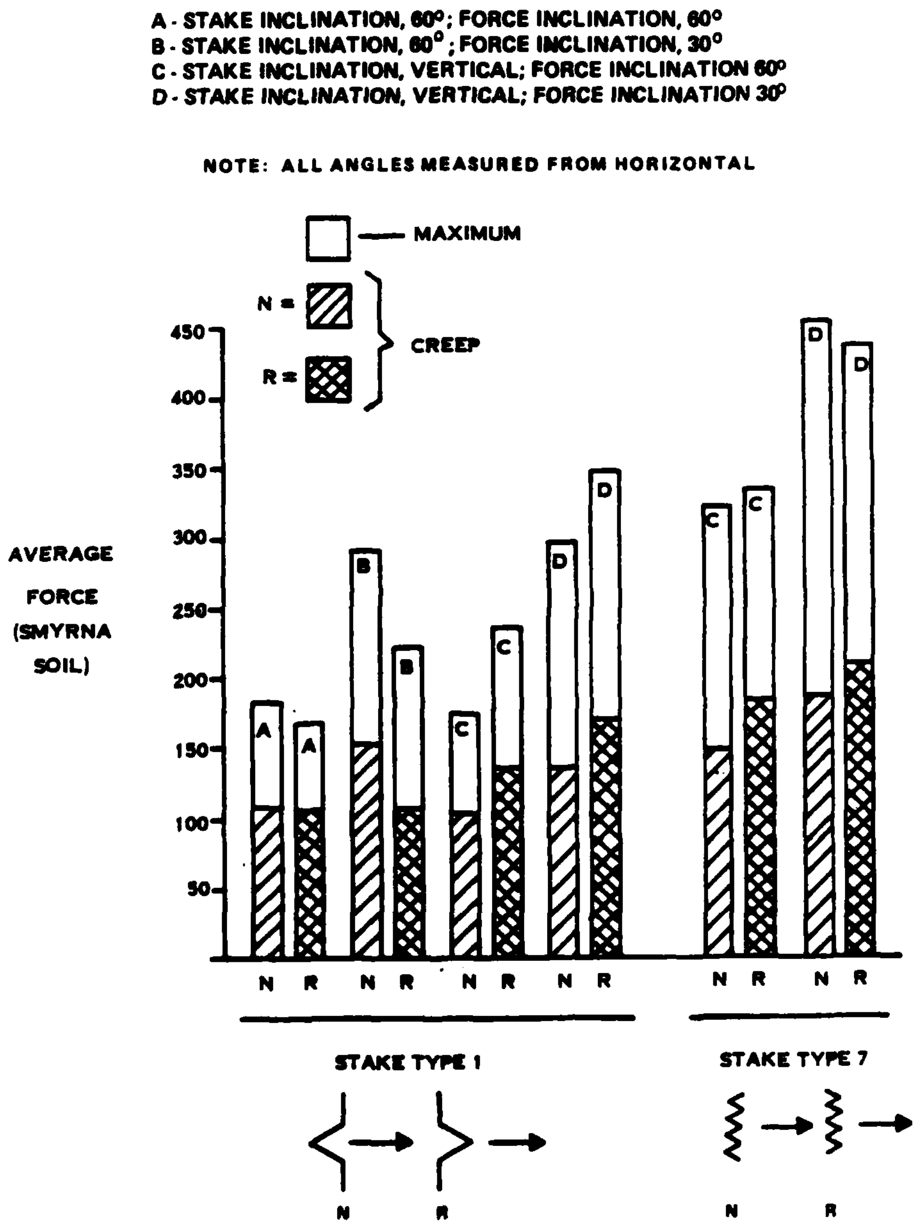



Figure 16 Effect of Reversing Stake Types 1 & 7

Table 3
Hardened Versus Unhardened Stakes in Smyrna Soil
(Average Resistance Forces, in Pounds)

| STAKE TYPE | STAKE INCLINATION | FORCE INCLINATION | UNHARDENED 1 June 1983[a] | | UNHARDENED 14 July 1983 | | HARDENED 14 July 1983 | | FORCE INCREASE Hardened minus Unhardened[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Creep | Max | Creep | Max | Creep | Max | Creep | Max |
| 6 | 60° | 60° | 160 | 269 | 208 | 287 | 234 | 389 | 26 | 102 |
| 6 | 60° | 30° | 219 | 335 | 242 | 335 | 251 | 458 | 9 | 123 |
| 6 | Vertical | 60° | 157 | 210 | 194 | 263 | 325 | 431 | 31 | 168 |
| 6 | Vertical | 30° | 249 | 343 | 366 | 433 | 406 | >500[d] | 40 | e |
| | | Average | 196 | 289 | 253 | 330 | 304 | >445 | | |
| 7 | 60° | 60° | 119 | 293 | 185 | 358 | 194 | >451[c] | 9 | >93 |
| 7 | 60° | 30° | 165 | 350 | 208 | 400 | 243 | >483[c] | 35 | >83 |
| 7 | Vertical | 60° | 149 | 321 | 262 | 395 | 270 | >485[c] | 8 | >90 |
| 7 | Vertical | 30° | 187 | 453 | 218 | >485[c] | 260 | >500[d] | 42 | e |
| | | Average | 155 | 354 | 218 | >410 | 242 | >480 | | |

NOTES:
a. Repeated from Table 2.
b. 14 July 1983 data only
c. Actual force unknown, Max scale reading was 500 lbs. for one or more trials
d. All trails exceeded 500 lbs.
e. Difference could not be determined since maximum force exceeded 500 lbs.

## Section 5

## CONCLUSIONS

The testing of the standard and developmental camouflage screen stakes has produced the following conclusions:

- The type 6 and type 7 stakes are superior in anchoring capability to the standard woodland camouflage screen stake (type 1) and to the arctic camouflage screen stake (modified) (type 3) regardless of soil type.

- The type 7 stake has greater anchoring capability than the type 6 stake in all soils and all stake/force geometries.

- The type 7 stake, although showing creep at a lower percentage of maximum force, still in most conditions actually resists a greater force before creep occurs than the type 6 stake.

- The stake/force geometry of vertical stake with a force inclination of 30° from the horizontal is superior to the other three stake/force geometries tested.

- The angle at which the force is applied to the stake affects the holding power of the stake to a greater extent than the angle at which the stake is driven into the ground.

- There appears to be little difference in which side of stake type 7 faces the force. When the type 1 stake is driven at an angle to the surface, it holds better with the normal side toward the force. When driven vertically, the type 1 stake holds better with the reverse side of the stake toward the force.

- The type 6 and 7 stakes in the unhardened configuration deformed under loads exceeding approximately 250 pounds.

- Hardening the type 6 and 7 stakes prevented bending under load and essentially eliminates battering.

## Section 6

## RECOMMENDATIONS

The following recommendations are based on observations and the results of testing the four types of stakes in three types of sandy soils in Volusia County, Florida:

- That, when anchoring capability in loose or sand type soils greater than provided by standard stakes is required to erect and maintain camouflage, the type 7 stake be made available for this purpose.
- That, to better resist battering and bending in useage, the type 7 stake be heat treated to greater hardness or that the gage of the metal be increased.

REFERENCES

1. "Camouflage Screening Support Systems", MIL-C-52765B(ME), 27 September 1977, Amendment 1, 10 February 1981

2. "Camouflage Screening Systems, Modular, Lightweight, Synthetic-Snow", MIL-C-52933(ME), 21 September 1977

3. "Camouflage Screening Systems, Modular, Lightweight, Synthetic", MIL-C-52711A(ME), 23 February 1976, Amendment 1, 11 February 1981

4. "Pins, Test, Metal", MIL-P-501, 4 December 1974

5. "Single Stake Holdfast Test, Soil-Virginia Loam, Mason's Farm - Fort Belvoir, Va.", Drawing G-9-D-3409, U.S. Army Corps of Engineers, The Engineer Board, Fort Belvoir, Va., Drawn 5-1-43.

6. "Test of New QM Cast Aluminum Alloy Ground Anchor And Navy Aircraft Mooring Anchor", Project 8-31-03-107, 6 April 1956.

7. "Soil Survey of Volusia County, Florida", United States Department of Agriculture, Soil Conservation Service, February 1980.

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APPENDIX

TEST DATA SHEETS

Stake Test Data Sheet

Number: 1

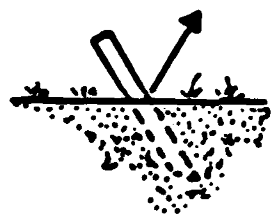
Test Date:

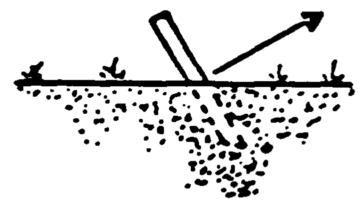
Test Site: 1

Stake Type: 1

Soil Type: Palm Beach Sand

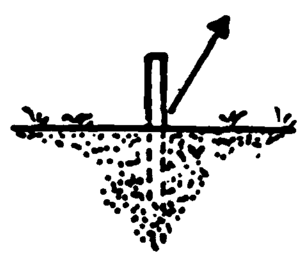
## Inclined Stake ($30^o$)

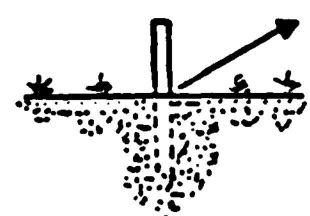




| | Inclined Force, $60^o$, Pounds | | Inclined Force, $30^o$, Pounds | |
|---|---|---|---|---|
| Trial No. | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 35 | 50 | 30 | 45 |
| 2 | 25 | 40 | 25 | 40 |
| 3 | 30 | 30 | 30 | 65 |
| 4 | 25 | 25 | 40 | 85 |
| 5 | 25 | 30 | 30 | 75 |
| Average | 28 | 35 | 31 | 62 |
| Standard Deviation | 4.47 | 10 | 5.48 | 19.24 |

## Vertical Stake





| | Inclined Force, $60^o$, Pounds | | Inclined Force, $30^o$, Pounds | |
|---|---|---|---|---|
| Trial No. | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 45 | 70 | 60 | 80 |
| 2 | 35 | 65 | 55 | 80 |
| 3 | *40 | *55 | 45 | 60 |
| 4 | 45 | 65 | 60 | 80 |
| 5 | 50 | 70 | 50 | 70 |
| Average | 43 | 65 | 54 | 74 |
| Standard Deviation | 5.70 | 6.12 | 6.52 | 8.94 |

Stake Test Data Sheet

Number: 2

Test Date: 18 April 1983

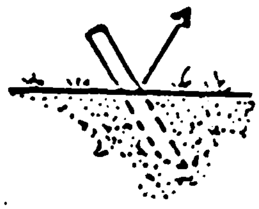
Test Site: 1

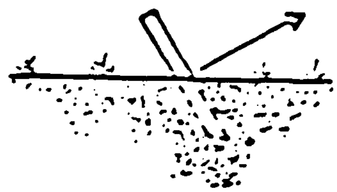
Stake Type: 3

Soil Type: Palm Beach Sand

| | Inclined Force, $60^{\circ}$, Pounds | | Inclined Force, $30^{\circ}$, Pounds | |
|---|---|---|---|---|

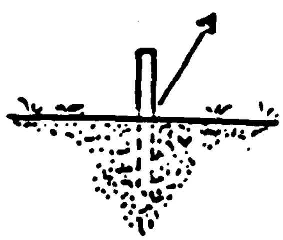
**Inclined Stake ($60^{\circ}$)**

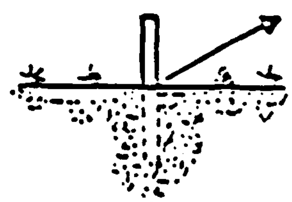




| Trial No. | $60^{\circ}$ CREEP | $60^{\circ}$ PULL-OUT | $30^{\circ}$ CREEP | $30^{\circ}$ PULL-OUT |
|---|---|---|---|---|
| 1 | 30 | 30 | 25 | 35 |
| 2 | 25 | 35 | 40 | 50 |
| 3 | 25 | 30 | 25 | 30 |
| 4 | 35 | 45 | 30 | 40 |
| 5 | 25 | 30 | 30 | 45 |
| Average | 28 | 34 | 30 | 40 |
| Standard Deviation | 4.47 | 6.62 | 6.12 | 7.91 |

**Vertical Stake**





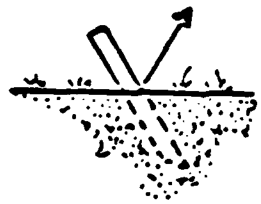
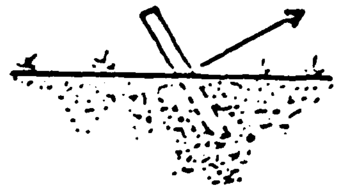
| Trial No. | $60^{\circ}$ CREEP | $60^{\circ}$ PULL-OUT | $30^{\circ}$ CREEP | $30^{\circ}$ PULL-OUT |
|---|---|---|---|---|
| 1 | 65 | 65 | 55 | 100 |
| 2 | 50 | 60 | 75 | 106 |
| 3 | 55 | 65 | 50 | 60 |
| 4 | 50 | 60 | 70 | 70 |
| 5 | 60 | 60 | 70 | 85 |
| Average | 56 | 62 | 64 | 84 |
| Standard Deviation | 6.52 | 2.74 | 10.84 | 19.17 |

Stake Test Data Sheet Number: 3

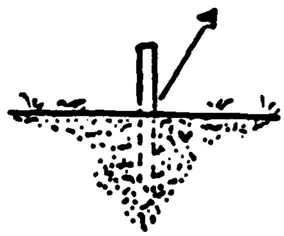
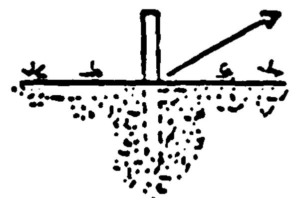
Test Date: 18 April 1983 Stake Type: 6

Test Site: 1 Soil Type: Palm Beach Sand

Inclined Stake (60°)

| | Inclined Force, 60°, Pounds | | Inclined Force, 30°, Pounds | |
|---|---|---|---|---|
| |  | |  | |
| Trial No. | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 70 | 85 | 65 | 90 |
| 2 | 60 | 75 | 50 | 70 |
| 3 | 80 | 105 | 50 | 225 |
| 4 | 85 | 125 | 50 | 75 |
| 5 | 80 | 95 | 55 | 75 |
| Average | 75 | 97 | 54 | 77.5 |
| Standard Deviation | 10 | 19.24 | 6.52 | 8.66 |

Vertical Stake

| | | | | |
|---|---|---|---|---|
| |  | |  | |
| Trial No. | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 40 | 50 | 100 | 150 |
| 2 | 65 | 65 | 110 | 165 |
| 3 | 130 | 135 | 100 | 135 |
| 4 | 85 | 100 | 135 | 185 |
| 5 | 80 | 125 | 80 | 100 |
| Average | 67.5 | 85 | 105 | 147 |
| Standard Deviation | 20.21 | 33.91 | 20.0 | 32.13 |

## Stake Test Data Sheet

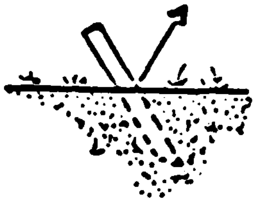
Number: [illegible]

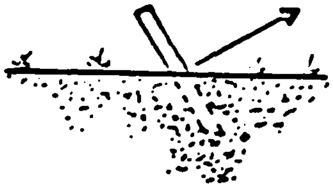
Test Date: 18 April 1983

Test Site: 1

Stake Type: 7

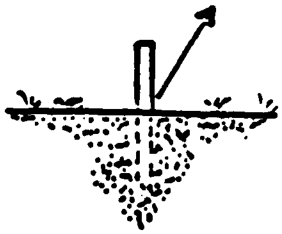
Soil Type: Palm Beach Sand

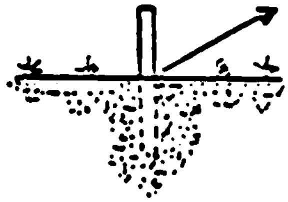




### Inclined Stake (60°)

| Trial No. | Inclined Force, 60°, Pounds | | Inclined Force, 30°, Pounds | |
|---|---|---|---|---|
| | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 100 | 150 | 100 | 130 |
| 2 | 65 | 95 | 75 | 115 |
| 3 | 70 | 110 | 75 | 180 |
| 4 | 95 | 150 | 70 | 140 |
| 5 | 75 | 100 | 65 | 145 |
| Average | 81 | 121 | 77 | 142 |
| Standard Deviation | 15.57 | 27.02 | 13.51 | 23.14 |





### Vertical Stake

| Trial No. | Inclined Force, 60°, Pounds | | Inclined Force, 30°, Pounds | |
|---|---|---|---|---|
| | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 100 | 130 | 110 | 195 |
| 2 | 120 | 155 | 115 | 205 |
| 3 | 140 | 185 | 125 | 280** |
| 4 | 150 | 165 | 115 | 175 |
| 5 | 145 | 195 | 100 | 195 |
| Average | 131 | 166 | 110 | 192.5 |
| Standard Deviation | 20.74 | 25.59 | 7.07 | 12.58 |

** Throw Out

## Stake Test Data Sheet

Number: 5

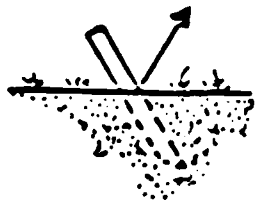
Test Date: **19 April 1983**

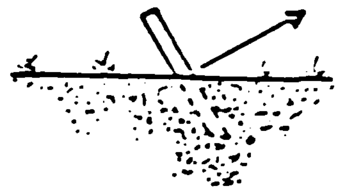
Test Site: 2

Stake Type: 1

Soil Type: Bulow Sand

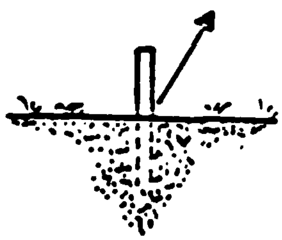
### Inclined Stake (60°)

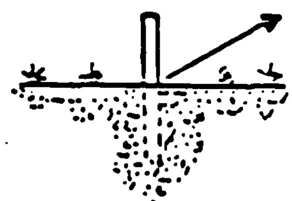




| Trial No. | Inclined Force, 60°, Pounds: CREEP | Inclined Force, 60°, Pounds: PULL-OUT | Inclined Force, 30°, Pounds: CREEP | Inclined Force, 30°, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 45 | 60 | 35 | 65 |
| 2 | 35 | 60 | 35 | 70 |
| 3 | 40** | 90** | 50 | 100 |
| 4 | 35 | 55 | 40 | 90 |
| 5 | 35 | 45 | 40 | 110 |
| Average | 37.5 | 55 | 40 | 87 |
| Standard Deviation | 5.0 | 7.07 | 6.12 | 19.24 |

### Vertical Stake





| Trial No. | Inclined Force, 60°, Pounds: CREEP | Inclined Force, 60°, Pounds: PULL-OUT | Inclined Force, 30°, Pounds: CREEP | Inclined Force, 30°, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 50 | 50 | 50 | 75 |
| 2 | 40 | 45 | 40 | 85 |
| 3 | 35 | 45 | 55 | 95 |
| 4 | 30 | 35 | 55 | 75 |
| 5 | 30 | 45 | 40 | 80 |
| Average | 37 | 44 | 48 | 82 |
| Standard Deviation | 8.37 | 5.48 | 7.58 | 8.37 |

****Throw Out**

Stake Test Data Sheet

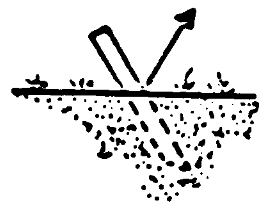
Number: 6

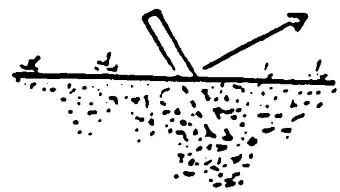
Test Date: 19 April 1983

Test Site: 2

Stake Type: 3

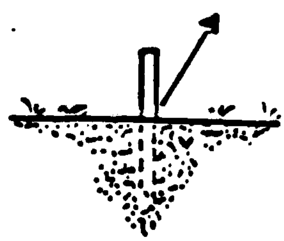
Soil Type: Bulow Sand

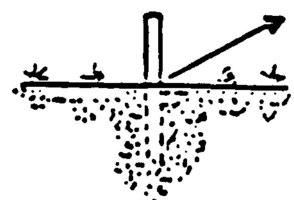




Inclined Stake (60°)

| Trial No. | Inclined Force, 60°, Pounds CREEP | Inclined Force, 60°, Pounds PULL-OUT | Inclined Force, 30°, Pounds CREEP | Inclined Force, 30°, Pounds PULL-OUT |
|---|---|---|---|---|
| 1 | 30 | 40 | 55** | 101** |
| 2 | 35 | 40 | 30 | 60 |
| 3 | 25 | 40 | 30 | 50 |
| 4 | 25 | 30 | 35 | 60 |
| 5 | 30 | 45 | 30 | 55 |
| Average | 29 | 39 | 31.25 | 56.25 |
| Standard Deviation | 4.18 | 5.48 | 2.5 | 4.79 |





Vertical Stake

| Trial No. | Inclined Force, 60°, Pounds CREEP | Inclined Force, 60°, Pounds PULL-OUT | Inclined Force, 30°, Pounds CREEP | Inclined Force, 30°, Pounds PULL-OUT |
|---|---|---|---|---|
| 1 | 45 | 50 | 45 | 90 |
| 2 | 50** | 80** | 40 | 75 |
| 3 | 40 | 55 | 35 | 55 |
| 4 | 45 | 50 | 40 | 65 |
| 5 | 35 | 45 | 35 | 65 |
| Average | 41.25 | 50 | 39 | 70 |
| Standard Deviation | 4.79 | 4.08 | 4.18 | 13.23 |

**Throw out

# Stake Test Data Sheet

Number: 7

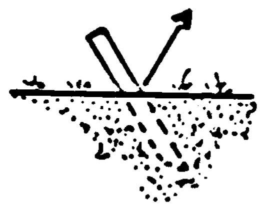
Test Date: **19 April 1983**

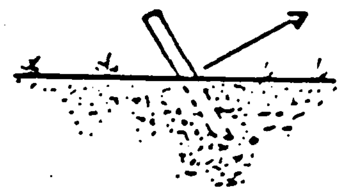
Test Site: 2

Stake Type: 6

Soil Type: Bulow Sand

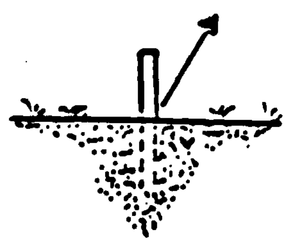
## Inclined Stake (60°)

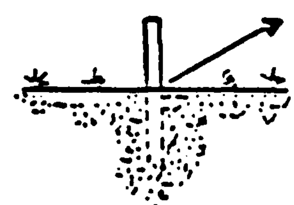




| Trial No. | Inclined Force, 60°, Pounds: CREEP | Inclined Force, 60°, Pounds: PULL-OUT | Inclined Force, 30°, Pounds: CREEP | Inclined Force, 30°, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 75 | 105 | 35 | 80 |
| 2 | 65 | 105 | 35 | 65 |
| 3 | 50 | 85 | 50 | 115 |
| 4 | 55 | 65 | 45 | 120 |
| 5 | 75 | 80 | 55 | 100 |
| Average | 64 | 108 | 44 | 96 |
| Standard Deviation | 11.40 | 43.53 | 8.94 | 83.29 |

## Vertical Stake





| Trial No. | Inclined Force, 60°, Pounds: CREEP | Inclined Force, 60°, Pounds: PULL-OUT | Inclined Force, 30°, Pounds: CREEP | Inclined Force, 30°, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 65 | 85 | 60 | 135 |
| 2 | 55 | 80 | 110 | 165 |
| 3 | 85 | 135 | 70 | 130 |
| 4 | 65 | 80 | 70** | 225** |
| 5 | 80 | 100 | 100 | 170 |
| Average | 70 | 96 | 85 | 150 |
| Standard Deviation | 12.25 | 23.29 | 23.80 | 20.41 |

**Throw Out

Stake Test Data Sheet

Number: 8

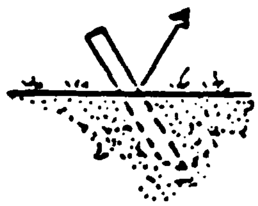
Test Date: 19 April 1983

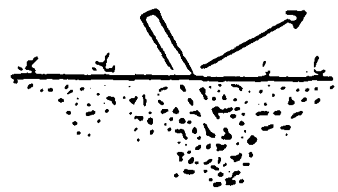
Test Site: 2

Stake Type: 7

Soil Type: Bulow Sand

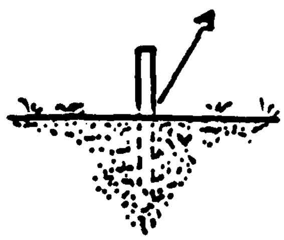
Inclined Stake (60°)

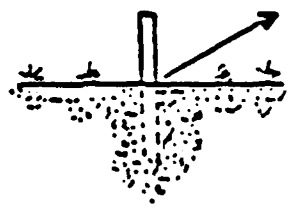




| Trial No. | Inclined Force, 60°, Pounds | | Inclined Force, 30°, Pounds | |
|---|---|---|---|---|
| | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 55 | 95 | 90 | 175 |
| 2 | 50 | 85 | 120 | 230 |
| 3 | 50 | 100 | 100 | 205 |
| 4 | 45 | 95 | 95 | 205 |
| 5 | 60 | 145 | 75 | 115 |
| Average | 52 | 104 | 96 | 186 |
| Standard Deviation | 5.70 | 23.56 | 16.36 | 44.22 |

Vertical Stake





| Trial No. | CREEP | PULL-OUT | CREEP | PULL-OUT |
|---|---|---|---|---|
| 1 | 75 | 115 | 80 | 145 |
| 2 | 85 | 115 | 85 | 160 |
| 3 | 70 | 105 | 90 | 245 |
| 4 | 80 | 120 | 95 | 245 |
| 5 | 65 | 105 | 100 | 210 |
| Average | 75 | 112 | 90 | 201 |
| Standard Deviation | 7.91 | 6.71 | 7.91 | 46.82 |

# Stake Test Data Sheet

Number: 3

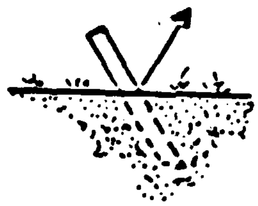
Test Date: **1 June 1983**

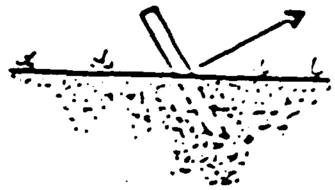
Test Site: 3

Stake Type: 1

Soil Type: Smyrna Sand

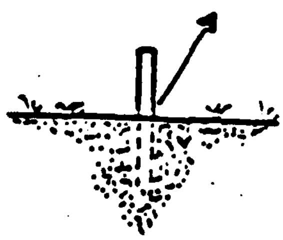
## Inclined Stake (60°)

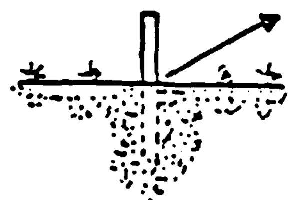




| Trial No. | Inclined Force, 60°, Pounds: CREEP | Inclined Force, 60°, Pounds: PULL-OUT | Inclined Force, 30°, Pounds: CREEP | Inclined Force, 30°, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 115 | 190 | 180 | 295 |
| 2 | 120 | 185 | 135 | 305 |
| 3 | 95 | 175 | 135 | 300 |
| 4 | 120 | 180 | 150 | 275 |
| 5 | 85 | 185 | 160 | 280 |
| Average | 107 | 183 | 152 | 291 |
| Standard Deviation | 16.05 | 5.70 | 18.91 | 12.94 |

## Vertical Stake





| Trial No. | Inclined Force, 60°, Pounds: CREEP | Inclined Force, 60°, Pounds: PULL-OUT | Inclined Force, 30°, Pounds: CREEP | Inclined Force, 30°, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 95 | 145 | 125 | 300 |
| 2 | 105 | 140 | 125 | 295 |
| 3 | 115 | 195 | 130 | 315 |
| 4 | 100 | 165 | 120 | 285 |
| 5 | 95 | 120 | 170 | 285 |
| Average | 102 | 173 | 134 | 296 |
| Standard Deviation | 8.37 | 20.19 | 20.43 | 12.45 |

Stake Test Data Sheet

Number: 9A

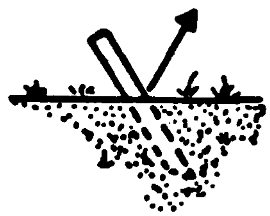
Test Date: 1 June 1983

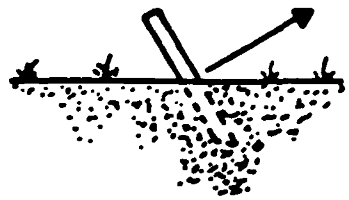
Stake Type: 1

Test Site:

Soil Type: Smyrna Sand

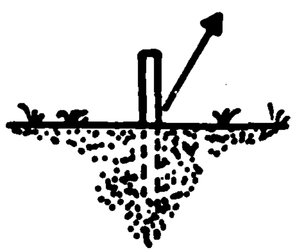
Inclined Force, $60^\circ$, Pounds | Inclined Force, $30^\circ$, Pounds

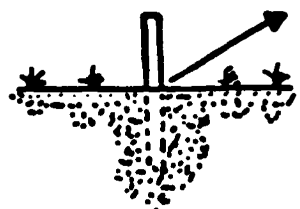




Reverse Inclined Stake ($60^\circ$)

| Trial No. | CREEP ($60^\circ$) | PULL-OUT ($60^\circ$) | CREEP ($30^\circ$) | PULL-OUT ($30^\circ$) |
|---|---|---|---|---|
| 1 | 125 | 165 | 100 | 230 |
| 2 | 95 | 140 | 110 | 220 |
| 3 | 95 | 200 | 115 | 215 |
| 4 | | | | |
| 5 | | | | |
| Average | 105 | 168 | 108.33 | 221.67 |
| Standard Deviation | 17.32 | 30.14 | 7.64 | 7.64 |





Reverse Vertical Stake

| Trial No. | CREEP ($60^\circ$) | PULL-OUT ($60^\circ$) | CREEP ($30^\circ$) | PULL-OUT ($30^\circ$) |
|---|---|---|---|---|
| 1 | 150 | 270 | 190 | 305 |
| 2 | 160 | 235 | 165 | 340 |
| 3 | 130 | 210 | 135 | 375 |
| 4 | 135 | 235 | 190 | 370 |
| 5 | | | | |
| Average | 143.75 | 237.5 | 170 | 347.5 |
| Standard Deviation | 13.77 | 24.66 | 25.14 | 32.27 |

Stake Test Data Sheet

Number: 11

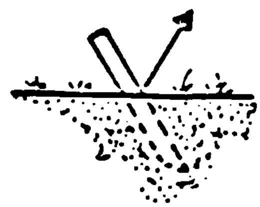
Test Date: 1 June 1983

Test Site: 3

Stake Type: 3

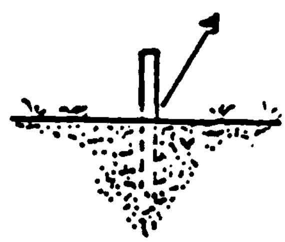
Soil Type: Smyrna Sand

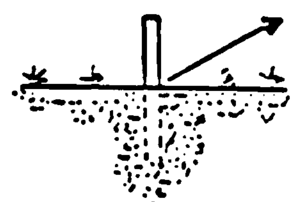
## Inclined Stake (60°)



| Trial No. | Inclined Force, 60°, Pounds | | Inclined Force, 30°, Pounds | |
|---|---|---|---|---|
| | CREEP | PULL-OUT | CREEP | PULL-OUT |
| 1 | 105 | 245 | 90 | 170 |
| 2 | 95 | 165 | 105 | 185 |
| 3 | 100 | 215 | 140 | 340 |
| 4 | 75 | 170 | 110 | 335 |
| 5 | 100 | 190 | 85 | 230 |
| Average | 95 | 197 | 106 | 216 |
| Standard Deviation | 11.73 | 33.28 | 21.62 | 138.18 |

## Vertical Stake





| Trial No. | CREEP | PULL-OUT | CREEP | PULL-OUT |
|---|---|---|---|---|
| 1 | 175 | 190 | 215 | 440 |
| 2 | 120 | 210 | 175 | 355 |
| 3 | 165 | 235 | 225 | 435 |
| 4 | 170 | 245 | 260 | 365 |
| 5 | 135 | 160 | 255 | 415 |
| Average | 153 | 208 | 226 | 402 |
| Standard Deviation | 24.14 | 34.39 | 34.35 | 39.62 |

## Stake Test Data Sheet

Number: 11

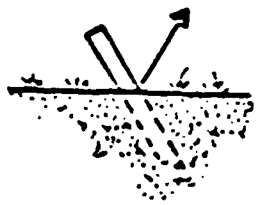
Test Date: **1 June 1983**

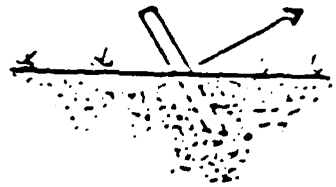
Test Site: 3

Stake Type: 6

Soil Type: Smyrna Sand

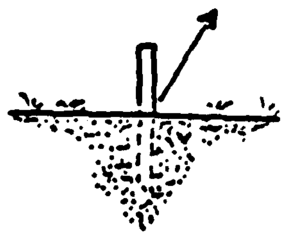
### Inclined Stake ($60^{o}$)

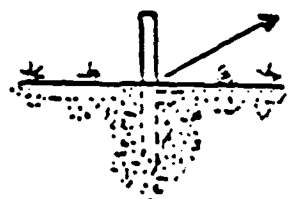




| Trial No. | Inclined Force, $60^{o}$, Pounds: CREEP | Inclined Force, $60^{o}$, Pounds: PULL-OUT | Inclined Force, $30^{o}$, Pounds: CREEP | Inclined Force, $30^{o}$, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 165 | 265 | 130 | 295 |
| 2 | 195 | 285 | 200 | 355 |
| 3 | 130 | 230 | 330 | 410 |
| 4 | 165 | 285 | 200 | 270 |
| 5 | 145 | 280 | 235 | 345 |
| Average | 160 | 269 | 219 | 335 |
| Standard Deviation | 24.49 | 23.29 | 72.84 | 54.66 |

### Vertical Stake





| Trial No. | Inclined Force, $60^{o}$, Pounds: CREEP | Inclined Force, $60^{o}$, Pounds: PULL-OUT | Inclined Force, $30^{o}$, Pounds: CREEP | Inclined Force, $30^{o}$, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | 170 | 215 | 170** | 390** |
| 2 | 145 | 210 | 240 | 355 |
| 3 | 165 | 235 | 270 | 360 |
| 4 | 160 | 205 | 230 | 305 |
| 5 | 145 | 195 | 255 | 350 |
| Average | 157 | 210 | 248.75 | 342.5 |
| Standard Deviation | 11.51 | 14.83 | 17.5 | 25.33 |

**Throw Out

## Stake Test Data Sheet

Number: 12

Test Date: 1 June 1983

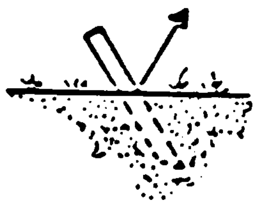
Test Site: 3

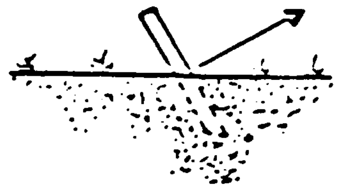
Stake Type: 7

Soil Type: Smyrna Sand

| | Inclined Force, 60°, Pounds | | Inclined Force, 30°, Pounds | |
|---|---|---|---|---|

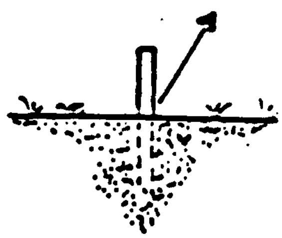
### Inclined Stake (60°)

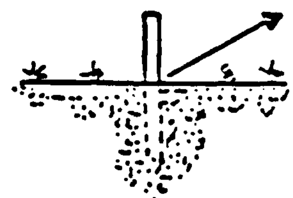




| Trial No. | CREEP (60°) | PULL-OUT (60°) | CREEP (30°) | PULL-OUT (30°) |
|---|---|---|---|---|
| 1 | 120 | 300 | 170 | 345 |
| 2 | 115 | 285 | 155 | 355 |
| 3 | 130 | 295 | 160 | 350 |
| 4 | 110 | 300 | 175 | 355 |
| 5 | 110** | 215** | 165 | 345 |
| Average | 118.75 | 292.5 | 165 | 350 |
| Standard Deviation | 8.53 | 11.90 | 7.91 | 5.0 |

### Vertical Stake





| Trial No. | CREEP (60°) | PULL-OUT (60°) | CREEP (30°) | PULL-OUT (30°) |
|---|---|---|---|---|
| 1 | 150 | 345 | 175 | 460 |
| 2 | 150 | 335 | 190 | 445 |
| 3 | 130 | 310 | 165 | 465 |
| 4 | 145 | 295 | 210 | 440 |
| 5 | 170 | 320 | 195 | 455 |
| Average | 149 | 321 | 187 | 453 |
| Standard Deviation | 14.32 | 19.81 | 17.54 | 10.37 |

**Throw Out

## Stake Test Data Sheet

Number: 12A

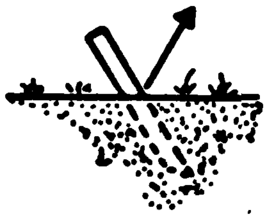
Test Date: 1 June 1983

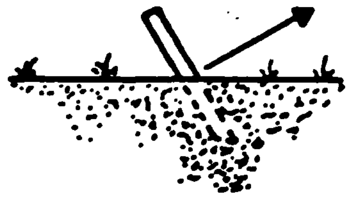
Test Site:

Stake Type: 7

Soil Type: Smyrna Sand

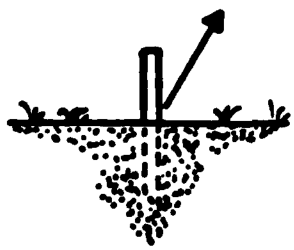
### Inclined Stake ($60^{\circ}$)

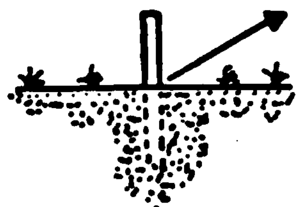




| Trial No. | Inclined Force, $60^{\circ}$, Pounds: CREEP | Inclined Force, $60^{\circ}$, Pounds: PULL-OUT | Inclined Force, $30^{\circ}$, Pounds: CREEP | Inclined Force, $30^{\circ}$, Pounds: PULL-OUT |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| Average | | | | |
| Standard Deviation | | | | |

### Reverse Vertical Stake





| Trial No. | $60^{\circ}$ CREEP | $60^{\circ}$ PULL-OUT | $30^{\circ}$ CREEP | $30^{\circ}$ PULL-OUT |
|---|---|---|---|---|
| 1 | 180 | 320 | 190 | 465 |
| 2 | 185 | 350 | 230 | 475 |
| 3 | 185 | 330 | 205 | 375 |
| 4 | | | | |
| 5 | | | | |
| Average | 183.33 | 333.33 | 208.33 | 438.33 |
| Standard Deviation | 2.89 | 15.28 | 20.21 | 55.08 |

Stake Test Data Sheet

Number: 13

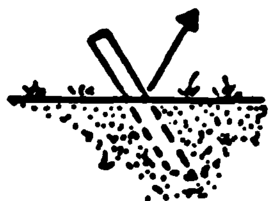
Test Date: 14 July 1983

Test Site: 3

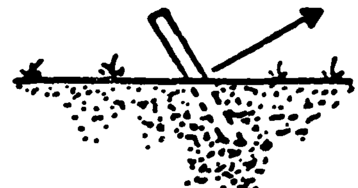
Stake Type: 6

Soil Type: Smyrna Sand

Inclined Force, $60^{\circ}$, Pounds

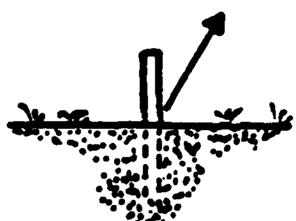


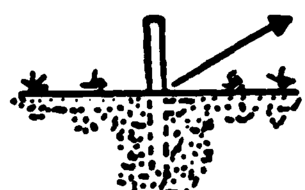
Inclined Force, $30^{\circ}$, Pounds



Inclined Stake ($30^{\circ}$)

| Trial No. | 60° NON-HARDENED CREEP | 60° NON-HARDENED PULL-OUT | 60° HARDENED C | 60° HARDENED P | 30° NON-HARDENED CREEP | 30° NON-HARDENED PULL-OUT | 30° HARDENED C | 30° HARDENED P |
|---|---|---|---|---|---|---|---|---|
| 1 | 230 | 290 | 230 | 390 | 200 | 295 | 260 | 445 |
| 2 | 190 | 280 | 245 | 360 | 260 | 345 | 245 | 445 |
| 3 | 205 | 290 | 225 | 430 | 265 | 365 | 255 | 450 |
| 4 | | | 235 | 375 | | | 245 | 490 |
| 5 | | | | | | | | |
| Average | 208 | 287 | 234 | 389 | 242 | 335 | 451 | 458 |
| Standard Deviation | 20.21 | 5.77 | 8.54 | 30.1 | 36.17 | 36.05 | 7.5 | 21.79 |





Vertical Stake

| Trial No. | 60° NON-HARDENED CREEP | 60° NON-HARDENED PULL-OUT | 60° HARDENED C | 60° HARDENED P | 30° NON-HARDENED CREEP | 30° NON-HARDENED PULL-OUT | 30° HARDENED C | 30° HARDENED P |
|---|---|---|---|---|---|---|---|---|
| 1 | 190 | 310 | 295 | 415 | 420 | 480 | 405 | >500 |
| 2 | 200 | 270 | 320 | 425 | 355 | 440 | 390 | >500 |
| 3 | 175 | 225 | 345 | 420 | 325 | 380 | 410 | >500 |
| 4 | 210 | 245 | 340 | 465 | | | 420 | >500 |
| 5 | | | | | | | | |
| Average | 194 | 263 | 325 | 431 | 366 | 433 | 406 | >500 |
| Standard Deviation | 14.93 | 36.63 | 22.73 | 22.87 | 48.55 | 50.33 | 12.5 | ? |

Stake Test Data Sheet

Number: 14

Test Date: 14 July 1983

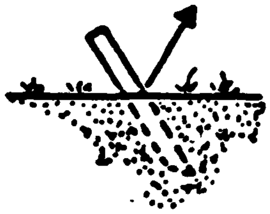
Test Site: 3

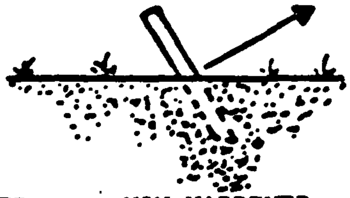
Stake Type: 7

Soil Type: Smyrna Sand

Inclined Force, 60°, Pounds

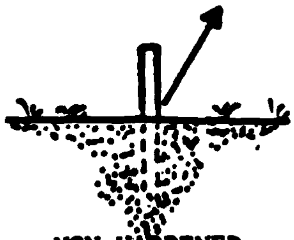
Inclined Force, 30°, Pounds

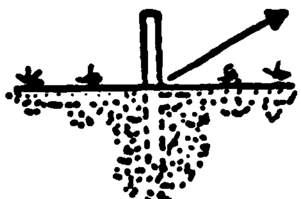




Inclined Stake (30°)

| Trial No. | NON-HARDENED (60°) CREEP | NON-HARDENED (60°) PULL-OUT | HARDENED (60°) C | HARDENED (60°) P | NON-HARDENED (30°) CREEP | NON-HARDENED (30°) PULL-OUT | HARDENED (30°) C | HARDENED (30°) P |
|---|---|---|---|---|---|---|---|---|
| 1 | 205 | 365 | 180 | >500 | 160 | 340 | 235 | >500 |
| 2 | 160 | 355 | 195 | >500 | 255 | 405 | 230 | 485 |
| 3 | 190 | 355 | 195 | 410 | 210 | 455 | 270 | 450 |
| 4 | | | 225 | 395 | | | 235 | >500 |
| 5 | | | | | | | | |
| Average | 185 | 358 | 198 | >451 | 208 | 400 | 243 | >483 |
| Standard Deviation | 22.91 | 5.77 | 18.87 | ? | 47.5 | 57.7 | 18.0 | ? |





Vertical Stake

| Trial No. | NON-HARDENED (60°) CREEP | NON-HARDENED (60°) PULL-OUT | HARDENED (60°) C | HARDENED (60°) P | NON-HARDENED (30°) CREEP | NON-HARDENED (30°) PULL-OUT | HARDENED (30°) C | HARDENED (30°) P |
|---|---|---|---|---|---|---|---|---|
| 1 | 285 | 420 | 260 | 445 | 240 | 495 | 265 | >500 |
| 2 | 245 | 390 | 280 | 465 | 165 | 460 | 240 | >500 |
| 3 | 255 | 375 | 270 | 435 | 250 | >500 | 260 | >500 |
| 4 | | | 270 | 430 | | | 275 | >500 |
| 5 | | | | | | | | |
| Average | 262 | 395 | 270 | 444 | 218 | >485 | 260 | >500 |
| Standard Deviation | 20.8 | 22.9 | 8.2 | 15.5 | 46.5 | ? | 14.7 | ? |

END

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